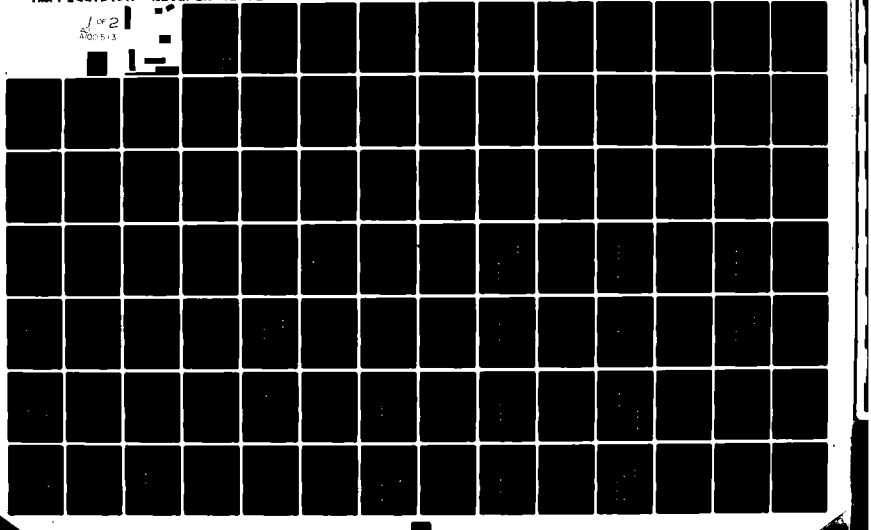
AD-A100 513 NAVAL WEAPONS ENGINEERING SUPPORT ACTIVITY WASHINGTON DC F/G 5/9
JOB PERFORMANCE AIDS TEST.(U)
NOV 72
UNCLASSIFIED NAVWESA-43-72 NL



LEVEL II

1

HUMAN FACTORS STUDY GROUP

JOB PERFORMANCE AIDS TEST

Report No. 43-72 November 1972

Prepared for the Commander, Naval Air Systems Command

(AIR-415B)

AIRTASK NO. A 260-415B-223D-2W45510003

NAVAL WEAPONS ENGINEERING SUPPORT ACTIVITY

WASHINGTON NAVY YARD
WASHINGTON, D.C. 20390

SUMMARY

A field test was made by the Human Factors Study Group of the Naval Weapons Engineering Support Activity at the request of CAMSI (Carrier Aircraft Maintenance Support Improvement), to determine the effectiveness of JPA's (Job Performance Aids) for the NC-8A for non-scheduled maintenance actions at the intermediate department level of three Naval Air Stations.

The results of the field test are reported.

A. Experienced technicians, performing simple (level I) tasks suitable to the JPA's format, provided error-free maintenance using the JPA's as a guide.

B. No significant difference in errors was found between inexperienced technicians performing all task levels suitable to the JPA's format and experienced technicians performing the same task levels under standard conditions, i.e.: without the JPA's guidance. Errors were not altered by the manual used.

C. A significant difference in time did exist between experienced technicians using the JPA's at task level I and performing the same task levels without the JPA's. The experienced technicians took longer to perform similar tasks when using the JPA's.

D. No significant difference in time existed for task level I jobs performed by inexperienced technicians using the JPA's and experienced technicians without the JPA's.

E. No significant difference in time existed for task level II jobs performed by experienced technicians with or without the JPA's.

F. No significant difference in time existed for task level II jobs performed by experienced technicians without the JPA's and inexperienced technicians with the JPA's for guidance.

G. The JPA's for the NC-8A were designed to avoid and not to encompass "troubleshooting." Therefore, the JPA's as written could not be used without assistance from an experienced troubleshooter.

H. Technical and procedural verification and "desk top" (readout) validation of the JPA's prior to the test proved fallible. The JPA's as received would not have been useable by non-trained personnel in any maintenance department. A

"hands on" validation as conducted in Phase II of the test proved a key prerequisite for use of the JPA's in such environment.

I. The results of the test indicate that inexperienced technicians using properly validated JPA's can adequately perform 34% of all non-scheduled maintenance actions with no penalty in time or errors. One fundamental factor in evaluating the JPA's based on a "remove and replace" structure is that in the remaining 66% of the cases, either because of a shortage of spare parts or the kinds of problems involved, malfunctions were repaired by methods not in the JPA's text, and in theory, "not required" by the book.

J. The field test indicated that by using a team consisting of one skilled "troubleshooter" and four technicians, without specialized schooling but using properly validated JPA's for guidance, all the normal non-scheduled maintenance activities can be accomplished with no increase in time or errors under actual operating conditions.

K. The test results indicate that the major significant advantage to the use of JPA's for non-scheduled maintenance at Naval Air Stations is the reduction in specialized schooling required.

The field test was conducted in three phases, involving 26 Navy technicians and required 6 months time to provide a total of 297 recorded OSD's (Operational Sequence Diagrams) of non-scheduled maintenance actions. The 54 OSD's exhibited in the appendix illustrate how problems are solved in a maintenance department, how job information is gathered and disseminated, how, when and where manuals are utilized, the effects of on-the-job-training in maintenance activity and the time required for specific tasks under standard operating procedures as well as a general view of the usefulness and limitations of JPA's. The OSD's also provide the basic data for "hands-on" time and error measurements.

Phase I of the test was conducted to determine the average time and errors involved for specific maintenance tasks under standard operating conditions. Phase II involved the "hands-on" validation of the JPA's and a measurement of the time and the errors involved in the use of the JPA's by experienced technicians. Phase III involved measurements of time and errors by inexperienced technicians using the JPA's for guidance.

The report contains a detailed description of all phases of the test program: how personnel were selected, how the

tests were conducted and observed and what was disclosed thereby. Specific data, the analyses performed, the maintenance errors found, the results of the "hands-on" validation of the JPA's, a complete list of the kinds of maintenance actions that were performed during the field test and all the calculations upon which the conclusions in the report are based are exhibited in the appendices.

CONTENTS
JOB PERFORMANCE AIDS TEST

CONTENTS PAGE 2

I. INTRODUCTION

A. JPA CONCEPT

A new type maintenance handbook has been under development for several years and is identified as a JPA (Job Performance Aid). It differs from current or "standard" maintenance manuals by providing step-by-step procedures combined with pertinent illustrations for the performance of maintenance tasks. All details of each maintenance operation are presented to the technician, obviating the need for reliance upon memory. It is hoped that through this means, maintenance tasks can be performed quickly and accurately by maintenance technicians who have not been given special training in the maintenance of a particular piece of equipment.

B. GENERAL INFORMATION

The question arises as to whether the "JPA" format is significantly better than that of the current maintenance manuals; and if it is, how much better? Is the improvement sufficient to justify changing from the current type manuals to the new type? The purpose of the test described in this report was to determine whether a significant difference exists under normal fleet maintenance operation. The test plan, field test program, and analyses were made in response to a request by CAMSI (Carrier Aircraft Maintenance Support Improvement) whose funding made it possible.

C. HISTORY

1. AIR FORCE TESTS

Between August 1968 and April 1969 the United States Air Force conducted tests to evaluate the effectiveness of the "JPA" type manual. Three behavioral effects were anticipated: a reduction in maintenance time, a reduction in the number of maintenance errors, and the ability to use inexperienced maintenance technicians without significant penalties in maintenance time or errors. The results of the Air Force tests indicate that after the initial learning trials, both experienced and inexperienced technicians using the JPA format performed error-free maintenance within the same time span as that of experienced technicians performing the same maintenance tasks and using the standard maintenance manuals. Thus, the JPA type manual seemed to have some advantage over the standard type.

2. NAVY TESTS

The Navy is currently using maintenance manuals that have remained essentially unchanged in intent and design since 1946. These provide essential reference

information for highly-trained maintenance specialists who are familiar with the equipment they are assigned to maintain and who require maintenance manuals for occasional reference use only. These manuals have been developed over many years by experts in this field and are generally considered to be effective and adequate. However, the search for ways to improve training and reduce maintenance time and errors, and therefore cost, must continue. The Military Commands should be aware of new possibilities, especially in light of increased equipment complexity and soaring logistic-support costs. One of the Job Performance Aids seems to offer opportunities for improvement in these areas and is, therefore, undergoing serious consideration.

II. PLAN

A. OBJECTIVE

The over-all objective of the plan was to develop a test and evaluation technique capable of being used to analyze the relative effectiveness of maintenance formats in order to facilitate the conducting of trials under fleet operating conditions. To accomplish this end, the Human Factors Study Group of the United States Naval Weapons Engineering Support Activity, hereinafter called the "observers," developed a plan and procedure (reference Appendix F) for conducting a study of unscheduled maintenance actions on a preselected item of GSE (Naval Aircraft Ground Support Equipment); the NC-8A Mobile Electric Power Plant. During the preliminary planning period, tests and evaluation procedures were determined and test material, sites, timetables and personnel were selected.

B. TASK COMPARISON BASIS

1. IDENTIFICATION

To compare the effectiveness of a new JPA on maintenance performance, the subjects to be compared must be identified. In this study, comparison was made between maintenance procedures as practiced under normal operating conditions and those conforming to the format of the new JPA. In order to determine a basis for future evaluation of data, it was necessary to identify a true time, or norm, for maintenance actions. In a laboratory environment, each maintenance technician would be assigned the same maintenance task several times to establish the norm for such a task and then compare that time to the results for the identical task action using the JPA format. In field testing, this is not possible, since unscheduled maintenance cannot be controlled without destroying one of the basic tenets of the test, i.e.; that tests shall be performed under normal operation conditions as they exist at the test sites, i.e.: Naval Air Stations. Given this factor, a necessary compromise had to be made. Instead of dealing with a one-to-one comparison of specified tasks, comparisons of tasks of similar nature and difficulty were made. The choice of determining the equivalence of tasks, therefore, was one of the most important factors taken into account.

2. TASK LEVELS

Unscheduled maintenance tasks were divided into three general group levels:

Class I (easy tasks, up to 45 minutes duration),
Class II (moderate tasks, from 1-3 hours duration),
Class III (difficult tasks exceeding 3 hours duration).

3. SCHEDULE

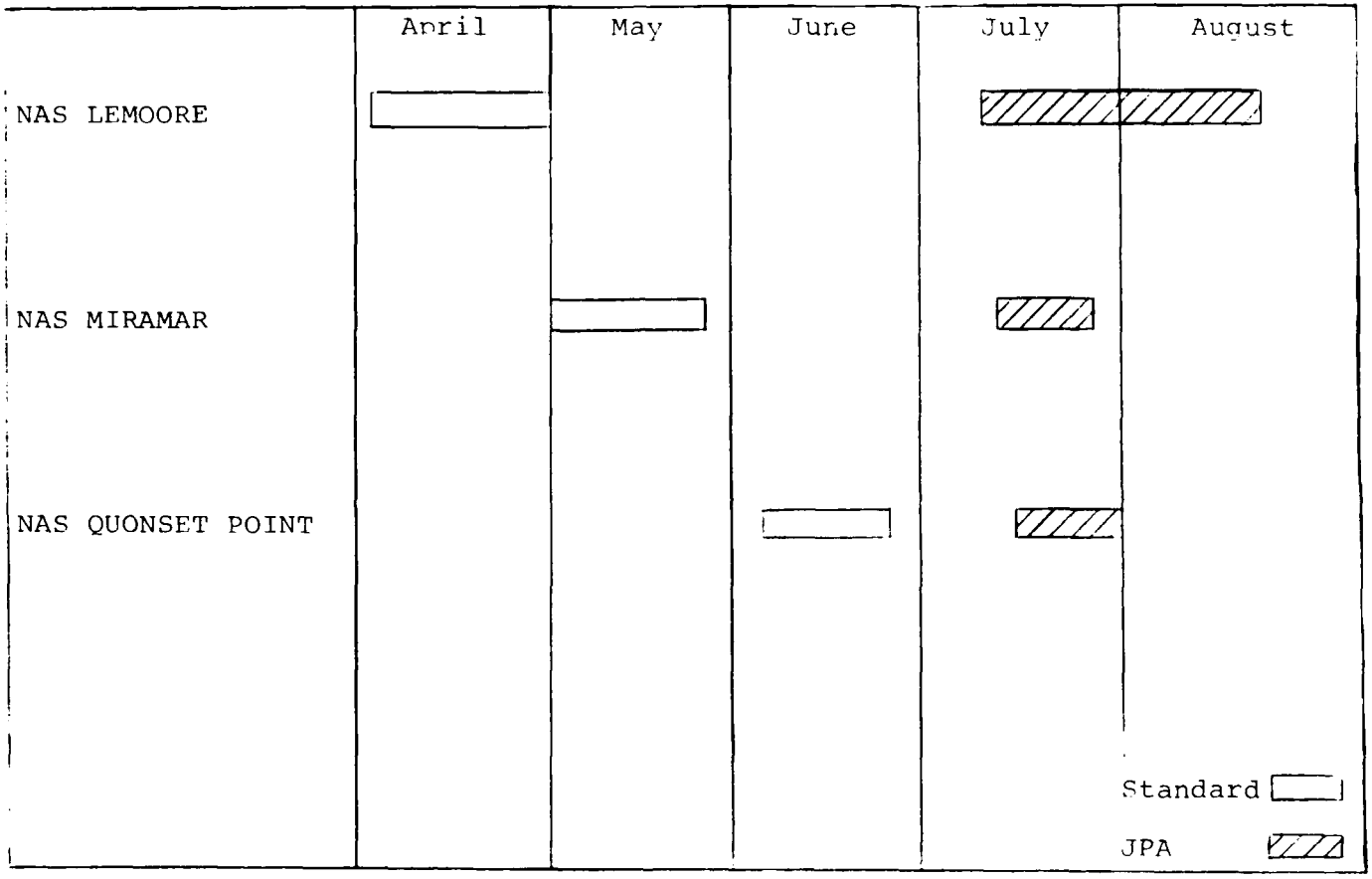
The schedule for conducting the tests is presented in Figure 1. As seen from the schedule, three Naval Air Stations were visited during a period of a little over four months. The test program involved 26 technicians and provided a total of 297 events. The particular tests made and the data used can be found in Appendix E.

C. TIMING - DURATION

During the first month of the tests, (Phase I), maintenance actions performed in the normal manner and using the standard maintenance manuals were observed and recorded. In the second month and thereafter, (Phases II and III), all maintenance actions were performed using the pertinent JPA's. These results were also recorded.

D. DATA RECORDING

All data acquired throughout the tests has been recorded on a Standard Data Sheet examples of which are presented as "Figure 1 through 54" in Appendix C. Their use assured uniformity of data acquisition and facilitated its' analysis.



NC-8A Job Performance Aid Test Program Schedule

Figure 1

III. BIAS

A. DIRECTIONAL BIAS

In the evaluation of the acquired data, the elimination of bias was vital to the success of the test because the object of the study was to determine if the Job Performance Aids format tested was inferior to, equal to or superior to the use of the current maintenance instructions. Bias due to errors in the directions given in the JPA were corrected during Phase II and were not held as accountable for "hands on" time or errors.

B. DAY OF THE WEEK

Bias due to the day of the week was noted in the standard work Phase I (Figures 2 and 3), but was not found during Phase II or Phase III. Although a comparison of errors versus work days in Phase I indicated a very noticeable peaking toward Wednesday with a maximum by Thursday, no such effect was found for the Phase II and Phase III sections of the test. Weighing of errors for the days of the work week was not used in the analysis of errors since the effect was negligible.

C. PERSONNEL

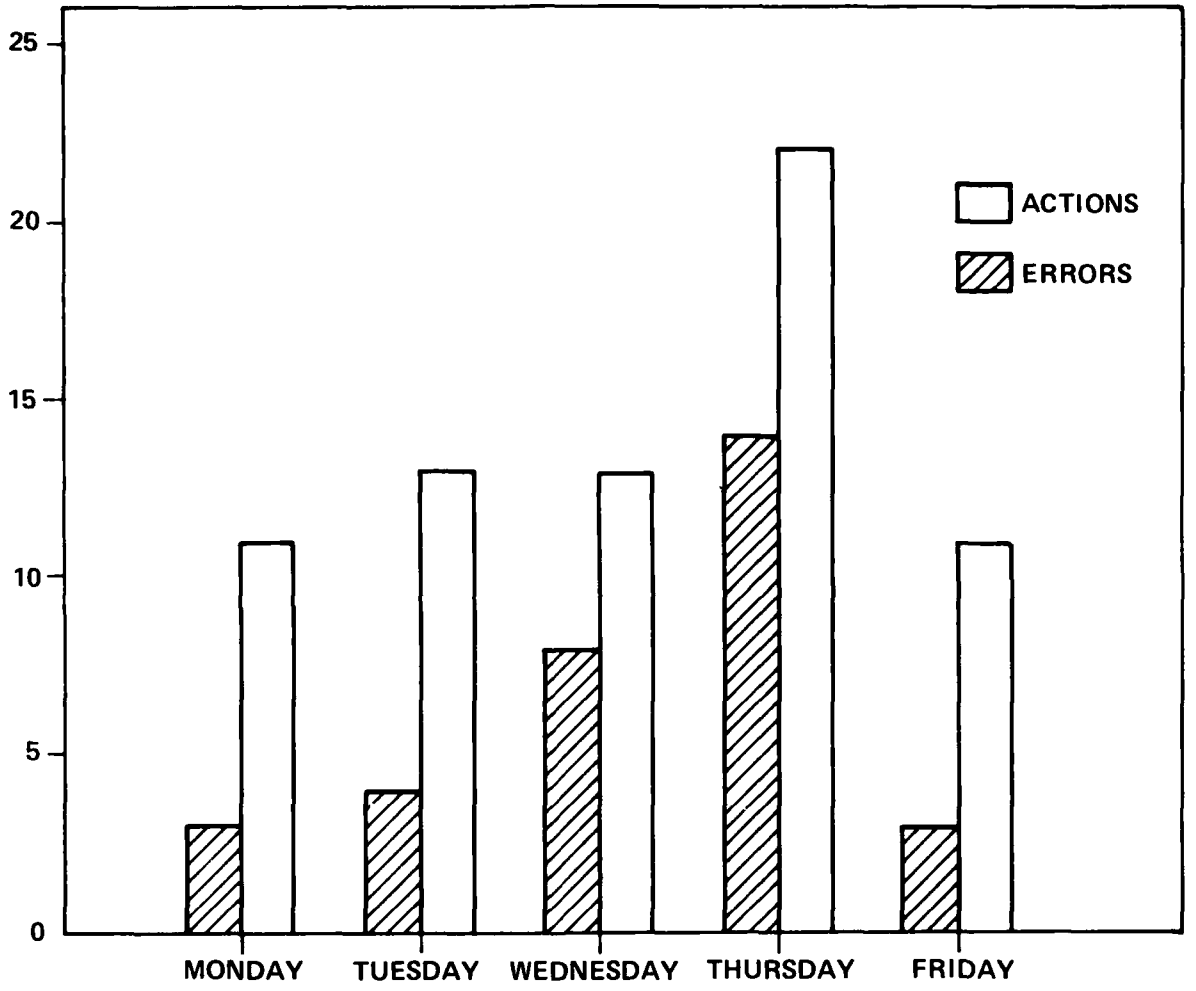
Bias due to particular personnel was found. One technician averaged a time for maintenance that was greater that the average of his co-workers by more than 2 standard deviations. He was therefore designated as a Code 2 operator and his time was not used in determining the average time for the maintenance action levels although it was used for the time for his group. The particular Code 2 operator was used for both Phases I and II of the test program. Another technician, found to be much faster than the norm determined for all regular operators, was identified as a Code 1 technician.

D. STATIONS

Bias between stations was checked by determining if the data received for all the tasks at the different stations could be considered the same set of data or differed sufficiently to indicate different sets. The "F" test at the .05 confidence level indicated the data received was all from the same set.

E. TASKS

Bias due to the choice of subjects used for the particular assignments given, or bias on the choice of tasks picked was eliminated by a randomizing technique. The tasks



NUMBER OF ACTIONS AND ERRORS BY DAY FOR PHASE I

Figure 2

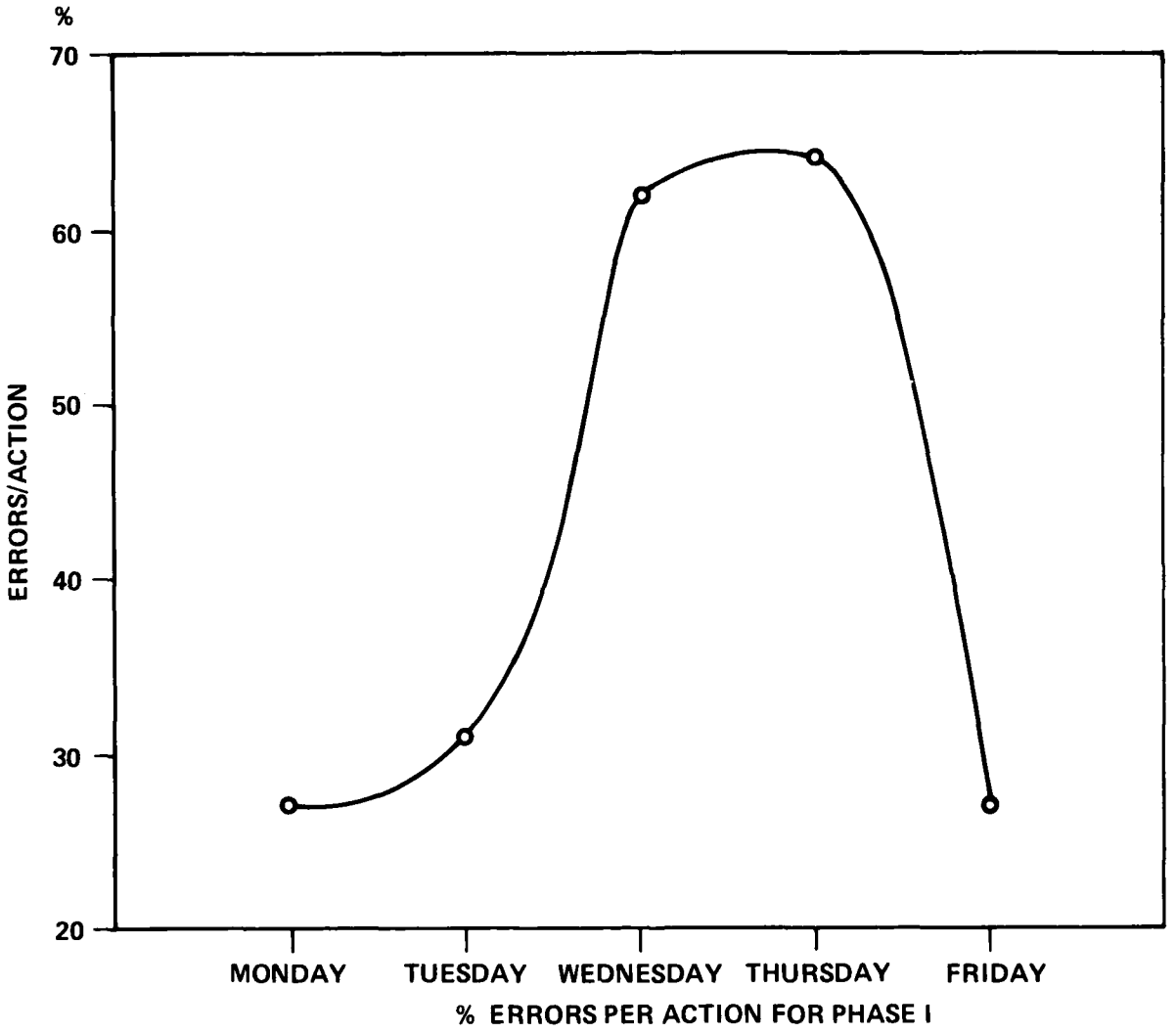

%
70
60
50
40
30
20
ERRORS/ACTION
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
% ERRORS PER ACTION FOR PHASE I

Figure 3

were assigned according to a pre-picked list of random numbers. Under normal operating conditions, it is understandable that complicated tasks are assigned to the most proficient technicians and the simple tasks to those with less training and experience. For statistical evaluation, randomization of job assignments and job complexibility was necessary. Randomizing the assigned tasks and using random numbers for the technicians served two purposes:

(1) It prevented any choice or bias on the part of the experimentor
(2) It prevented bias in tasks given to the subjects.

F. LEARNING

Bias due to the learning process was expected, but could not be determined from the limited data received. Initially a much larger data collection was expected for Phases II and III based on the activity during Phase I. However, during the test period the activity at the intermediate maintenance department dropped because over two-thirds of the aircraft squadrons involved were removed from the station. As a result, the lack of repeated assignments under actual field conditions prevented any significant differences due to learning to be available for analysis.

IV. SELECTION

A. EQUIPMENT

The NC-8A Mobile Electric Power Plant selected for field-testing is relatively new and has an operational failure rate severe enough to offer a high maintenance potential. For test purposes, this equipment also fulfilled the desired prerequisites in that it was sophisticated enough to be relatively difficult to repair, available in sufficient numbers in actual daily use, and geographically accessible.

B. STATIONS

1. REASONS

A preliminary investigation disclosed that Naval Air Stations situated on the West Coast offered not only the highest count of NC-8A's in daily use, but that aircraft operational activity was greatest, thereby offering the highest potential shop maintenance activity on this equipment per unit of time.

2. SITES CHOSEN

a. NAS (Naval Air Station) Lemoore, California, had 67 NC-8A units assigned. Of these, 23 were in use or "operational ready" status at the time of site selections, and with a reported average of 4-8 non-scheduled maintenance actions occurring daily.

b. NAS Miramar, California, had 37 units assigned, 31 of which were in use or "ready" status and an average of 6-8 daily maintenance actions were reported.

c. The possibility of unpredictable work slowdowns occasioned by fluctuating aircraft flight-line activity at these two before-mentioned stations, which would directly affect maintenance flow on Ground Support Equipment and thereby jeopardize the collection of data, was considered. An alternate site was chosen as a source to augment data already collected. This selection was NAS Quonset Point, R.I. Figure 1 shows the NC-8A test program schedule used.

C. PERSONNEL SELECTION

1. TECHNICIANS

It was decided to utilize regularly assigned enlisted personnel in the mechanical and electrical work centers within the GSE maintenance division shops at each station. Four men were assigned from each of the above-

named work centers at all stations involved, with assurances from the test stations that the identical technicians would remain in the test program for the duration of the study.

2. OBSERVERS

Study group engineering "observers" were selected from personnel assigned to the Human Factors Laboratory Section, Naval Weapons Engineering Support Activity who were specifically trained for this task. Where the work centers within the GSE shops were departmentized and physically separated, two observers were employed at one time.

V. PROCEDURES FOLLOWED

A. PHASES

1. STANDARD - PHASE I

A typical GSE Shop maintenance performance observed by the study group during Phase I of the test proceeded as follows:

a. A specimen NC-8A unit assigned to Squadron "X" of NAS failed in flight-line service.

b. The unit was turned in for corrective maintenance at the GSE Receiving and Dispatch Office. The "gripe" was verbally disclosed by the equipment operator to the receiving inspector who attempted to determine the validity of the "gripe".

c. When accepted for maintenance, the defective unit was replaced from units in the "up" line. The defective unit was then sent to the "awaiting maintenance" or "down" line.

d. A work order was prepared, identifying the equipment by serial number and describing the "gripe" or fault. The work order was then forwarded to the maintenance control office.

e. The work order was later picked up by the appropriate work center (mechanical or electrical) and the job assigned to a technician by the work center supervisor. Normally, job assignments are made at the discretion of the supervisor. However, for purposes of the test, as previously noted, technican assignments were selected by means of random numbers.

f. The technician assigned a maintenance task then used the work order as a guide. He first proceeded to determine if the "gripe" or designated fault was valid. At this point he either proceeded with the necessary repairs or started troubleshooting, followed by the necessary repair or replacement and testing of components. Under these "normal" operating conditions, the technician relied upon his own level of professional expertise. He was also assisted by means of reference to the standard manual, the availability of fellow-technicians, and the work center supervisor.

g. Upon completion of the maintenance requirements, each unit was given a minor "PM" (preventative maintenance) check: battery electrolyte, cooling system, etc.

h. The unit was then road-tested for propulsion, brakes and steering functions.

i. The next procedure was to connect unit to a load bank where it was tested for "full load operational performance."

j. The final step for the technician was to wash the vehicle and deliver it to the Dispatch Office as completed and "ready for issue."

k. If approved, it was sent to the "up" line.

1. If disapproved, it was returned directly to the appropriate work center.

2. "JOB PERFORMANCE AIDS" PHASE II

a. The second part of the test program was designated as "Phase II." Under this phase, the first "comparative" tests were conducted. All procedures outlined for Phase I ("standard" conditions) were identical, with the exception that under Phase II, maintenance actions were restricted to the exact procedures directed by the new "Job Performance Aids" format.

b. One of the important behavioral effects anticipated from the use of JPA's is the ability to use inexperienced maintenance technicians without significant penalties in maintenance time or errors. The degree of "inexperience" has varied. For the test program proposed, it was decided to attempt to determine only if the Navy specialized schooling could be omitted. Therefore, personnel that could have been accepted for schooling were to be used. Equally important, the tests were to provide actions that were normal to the Navy system. Given the limits of time and funding as well as the personnel available, it was decided to use the same personnel that had been used to establish the normal time and error information for that portion of the test that would indicate the effect of the JPA on non-specialized personnel.

c. A list of random numbers was used for each work center at each Study Site (Naval Air Station). Since four subject technicians were assigned from each work center (mechanical and electrical), two sets of four random numbers were used. The sets of random numbers dictated the order in which job assignments were made. The names of the technicians were alphabetized and identified from the first set of random numbers. Thus a typical block of random numbers for four (4) technicians could read: 3124-2413-1423-4123-2134 etc. Then alphabetically, and from the first block, "Bob" = 3, "Carl" = 1, "Ed" = 2 and "George" = 4. From then on, the task assignments would follow the sequence of the groups of random numbers commencing with group 2: the first task to No. 2 technician, the second to No. 4, third to No. 1, fourth to No. 3, fifth to No. 1 (next group), etc.

3. JOB PERFORMANCE AIDS - PHASE III

a. Phase III of the comparative tests, was conducted to determine whether maintenance could be performed adequately by untrained technicians. Here, an interchange of assigned technicians was made. Technicians in the mechanic shop were assigned each task on NC-8A's in the

electric work center and technicians from the electrical shop were assigned to tasks undertaken by the mechanical work center. Under this phase of the tests, the technicians were not trained in the field to which they were assigned. Using the same maintenance technicians for all sections of the test provided one direct advantage: bias due to the personnel involved would cancel. Shifting the personnel who were mechanics to the electrical shop provided technicians who were familiar with the gear although they did not know electronics. They were shown how to use a soldering iron, how to use the voltmeter and taught what some of the electronic parts were called. The electrical shop personnel who were transferred to the mechanical shop for the test were, in general, familiar with hand tools and required only a briefing concerning the general rules of the shop and the use of heavy-duty equipment. The results are reported in Section VI, A, 4-f.

b. Because the technicians were unfamiliar with the "gripes" they were assigned to correct, they were incapable of "troubleshooting" to determine corrective actions. Therefore, one additional qualified technician in each work center was designated as the "troubleshooter." He determined the fault in each case and specifically directed the maintenance actions to be performed. Under Phase III conditions, one further deviation from Phase II conditions was necessary. At the completion of each job, inspection and approval by the work center supervisor was required to assure a "ready for issue" status of the unit.

4. "OBSERVER" PERFORMANCE

The study group observers identified each NC-8A entering a work center for non-scheduled maintenance. All pertinent information was recorded on a data sheet (Figures 1 through 54 of Appendix C) as follows:

(1) Date of observation
(2) Station (NAS)
(3) Maintenance control number assigned
(4) Unit serial number
(5) "Gripe" or fault listed
(6) Assigned technician's rating (Electrical/ Mechanical)
(7) Type manual (standard/JPA)
(8) Operation "number"

The observer recorded starting time and all actions performed to the completion of the job. Each specific action was timed and identified by use of an OSD (Operational Sequence Diagram). By this means, actual "hands on time" was recapped in each case for the total maintenance action. The operational diagrams also identified the time to locate

fault (troubleshooting), time consumed in reference to the JPA, time for removal and installation of components, time for actual repair actions, time to assemble tools, the time spent in requisitioning parts, time elapsed for "work breaks" of any nature, errors made, "PM" (preventative maintenance) and other procedures not connected with the actual task assignment. Where physical help was needed, the additional "hands on time" of the assistant(s) was included in the total recorded. Such events made up the diffcrence between total "start to finish" time and actual "hands on time."

B. VALIDATION

1. REASONS

The JPA's written for the NC-8A were new manuals, which had not been validated and therefore had to be checked before they would be available for the test program. The JPA's consisted of four volumes, the first three of them directly concerned with "remove and replace" activities and the fourth involved with the fault finding aspects of the "trouble light" system.

2. METHOD

The validation was performed during the week of 15 May 1972 at NAS Lemoore under the cognizance of the Human Factors "observers." Four men from the GSE Shops; two mechanics experienced in maintenance of the NC-8A and two electronics specialists also experienced with the NC-8A read the volumes concerning work in their own areas. They looked for statements that were not clear, errors in fact or ommission, errors in direction or procedure etc. They read every word on every page during a period of four days. At the end of that time, the first three volumes of the JPA's had been covered. The fourth volume was not validated. The validators did not concern themselves with spelling or typographical errors; these were considered as minor and not critical to the JPA's use. Although a number of changes were made as a result of their work, the final copies still contained numerous errors that were not detected at that time.

3. LIMITS

One fundamental factor that must be considered in evaluating this JPA based on "Remove and Replace" structure is the fact that it applied only to 34% of the non-scheduled maintenance that occurred during the test period. In 66% of the cases, either because of the shortage of extra parts or the kinds of problems involved, the part was either repaired or altered in some fashion that was not in the text and in theory, "not required" by the book. In order to allow the test to be performed such actions were allowed, but were not charged to the job as "hands on" time. The repairs and

other adjustments were either performed by experienced men in the normal operation of their tasks or were done by the inexperienced men with instructions by the troubleshooters. In the "pure", no external help, concept of the use of the JPA, the jobs could not have been done.

4. TROUBLESHOOTING

The JPA for the NC-8A was designed to avoid and did not cover troubleshooting, yet in practice most of the "gripes" did not specify what had to be removed in order to bring the gear (NC-8A) back into normal operation. A study of the performances and normal working arrangement of the GSE Shop Phase I, indicated that the average mechanic and electronics specialist would troubleshoot the equipment thus verifying the written "gripe" or, if in error, he would determine the extent of the problem that actually existed. (The question of "what to remove and replace" in order to "fix" a malfunction was not in the JPA text nor would it be within the knowledge and experience of new technicians.) Therefore, the JPA as written could not be used without someone capable of providing the essential task decisions. No attempt was made to operate the shops without the use of any trained personnel.

VI. TEST

A. PROGRAM

1. INTRODUCTION

The test consisted of three phases. The first determined how the different stations operated for the normal maintenance cycle. The second allowed the experienced mechanics to do their job requiring only that it be done by the book, thus effectively determining the correctness of the text and providing the subjects with the essential experience of how to use the text. The third phase of the test used mechanics for electrical repairs and electronic specialists for mechanical maintenance.

2. PHASE I

In order that the difference the JPA made in a Navy maintenance system can be understood, the system without the JPA must be explained. Under the normal operating procedure, when a mechanic is given a task unfamiliar to him, he proceeds to find out what must be done by asking those who have done the job before. Data Sheet 16 shows an example of such behavior. In rare instances, he will look at the standard manual to obtain information. The records taken as part of this test, samples of which are presented in Appendix C, to establish the standard maintenance activities, indicate that if the use of the wiring diagrams and the parts lists in the standard manual is disregarded, the standard manual was used in less than 5% of the maintenance actions. The individual given a new task, using the JPA, looks it up in the index, finds the proper page and volume, and proceeds to do the job. Since he knows that the task can be done "by the book" he does not need outside help. In the "test" he could not go beyond the troubleshooter for help and therefore there are no records of such actions. The results are presented in Section VI, A, 4-f.

3. PHASE II

a. The test program was intended to determine the value of the JPA's. Therefore, in order to ensure that no bias due to errors in printing or in the instructions given existed, the JPA used had to be correct. Two questions had to be asked and the answers determined. One; Could the directions given in the JPA be followed by a skilled technician, i.e., were they technically correct? and two; Could the directions be followed without error by an unskilled technician, i.e., were they clear? Phase II would answer the first question and when it became affirmative, Phase III testing would follow and answer the second.

b. The Job Performance Aids as received, after verification and desk top validation would not have been useable by non-trained personnel in any maintenance department. The errors and omissions were sufficient to prevent useful work in many cases and would have reduced confidence over all to the point where it is doubtful that any reference to it would have been made when information was required. However, the first two weeks of the test of the text (Phase II) served a number of purposes:

(1) It provided experience to the mechanics and electronic specialists in how to use the JPA and how to find particular sections.

(2) It provided a "hands-on" check of the JPA.

(3) It provided known corrected JPA for both shops.

(4) It provided the "observers" with information concerning the time it would take experienced personnel to perform known maintenance actions using the steps as outlined in the JPA.

c. Each technician was given a set of JPA for his use during the test and was told that he was to "determine if the job could be performed by following the exact steps outlined in the book." If errors were found the technician was to call it to the attention of the available "observer" who would note it as a correction in the master copy JPA that he carried. The subject would correct his own copy and as time permitted correct the other sets of JPA's in the Intermediate Maintenance Shop.

d. The "hands on" checking provided proof that the revised JPA had errors of omission and direction. A "hands on" validation was essential before the JPA could be useful for untrained personnel. However, before Phase II was finished, the corrected JPA's were essentially error-free.

e. Phase II was intended to provide information and data concerning the effectiveness of correct JPA when used by experienced operators. Would the use of JPA's decrease the number of errors by experienced technicians in performing unscheduled maintenance? Would the JPA's increase or decrease the total "hands on" time required by experienced personnel? Would JPA's improve or degrade the present system if they had to be followed? Phase II provided data concerning skilled technicians using the JPA's.

4. PHASE III

a. The JPA's revised and corrected in Phase II could be used for the intermediate shop maintenance. However, part numbers are found in the old manual and it is necessary to refer to the old manual for such data. This was by

intent, since the part numbers and lists were known to be so available.

b. Phase III was intended to determine if inexperienced technicians using the JPA could perform regular unscheduled maintenance on the NC-8A in an operating environment. The design of the JPA's for the NC-8A however, imposed certain constraints on what could be done. The JPA's do not provide information leading to the determination of what to remove nor do they provide a way of determining that the part removed will be bad or the installed part good. When "remove and replace" does not cure the "gripe" the questions remain: Was the original part actually good, was the removal in error, and what additional work must be performed? The use of someone as a troubleshooter capable of answering these questions was a necessity if real maintenace was to be performed.

c. From the technicians available in the regular experienced crews, one was picked to become the troubleshooter for the electrical non-scheduled maintenance, another for the mechanical non-scheduled maintenance.

d. The technicians involved in the test program were informed that they would be told what to remove and replace by the "troubleshooter." If they were curious as to "why," they could ask the troubleshooter since such information was not in the JPA nor was it required in order that they be able to perform their tasks. As a result, those that desired to "know" would in time increase their understanding. Those not interested did not ask questions. The technicians were further informed that they were to "use their heads." If a step was not clear and they could not see how they could follow it, they were to ask the "troubleshooter." They were not expected to follow the directions without thought, although the text that they were given had been checked and was now correct. Under the conditions stated, no one found the text beneath his abilities; no one felt it was too simple.

e. Short cuts were not allowed, although the technicians were told that if they could think of one, they were to bring it to the attention of the "observers" for approval. However, in almost every instance, this was found to be difficult and actually did not save time. (This was not part of the test as such, but was felt would increase the cooperation of the personnel involved in the program and could improve the text's usefulness.)

f. The final phase was the critical one. With the participation of the troubleshooter as a key man plus inexperienced technicians with the JPA for guidance, the regular maintenance activity of the GSE shops was carried out. The result of the test indicated that with "hands on"

verified JPA's it was possible to use inexperienced technicians to perform non-scheduled maintenance without any time penalties; that personnel capable of completing a Navy School for specialization are capable of providing maintenance support action without attending such a school, provided they are given JPA's and a troubleshooter. They can relieve the skilled mechanic and electronics experts of approximately one-third of the workload without altering the present system in intermediate maintenance and with no penalty to the department. With a change in the system to a troubleshooter and crew, untrained personnel can do all the regular intermediate non-scheduled maintenance for the NC-8A's with no penalty in time or errors.

B. DATA SHEETS

1. The data sheets, by use of OSD's (Operational Sequence Diagrams), illustrate maintenance actions performed. They also contain task levels, code numbers, and group numbers. A glossary of the symbols used can be found on page 2 in Appendix C.

2. "Task Level" refers to the length of time the job normally takes, i.e., Task Level I less than 45 minutes, Task Level II less than 3 hours while Task Level III is greater than 3 hours of "hands on" time.

3. The "Code" shown has four values which are used only for those conditions where the results could bias the data. Code 1 refers to an exceptionally fast worker, Code 2 to an exceptionally slow worker, Codes 3 and 4 refer to physical conditions and were not required for these tests. In those instances where the Code 2 is used, it can be expected that the total time spent will be greater than the average for such a task, "hands on" time will be greater than the standard, assistance will generally be required and errors can be anticipated. In those instances where the Code 1 is used, it can likewise be expected that the "hands on" time will be less than "normal," that errors will be few if any, and that the subject is an expert and will tend to give information rather than receive it.

4. The "Group Number" on the data sheets indicates the conditions of the test. Group I data sheets represent Phase II, Group II data sheets "Phase I, Standard Manual," Group III data sheets represent the Phase III section of the test. Group IV, V, and VI contain maintenance actions that required more than 3 hours to complete (Level III jobs) with Group IV using the Standard Manual and Group V and VI demonstrating the use of the JPA's. The last three groups provide an insight into the actions of the shops when more difficult jobs are undertaken.

5. Data sheets 1-54 cover many of the maintenance actions recorded during the field test. For the benefit of readers unfamiliar with the symbols used, the actions shown are also described in Appendix C.

6. Ninety-nine events could not be used for the analysis. Some had to be voided because of observer's errors at the start of the test, others were voided due to actions that were not included in the correct programed test procedure, still others after checking and study, did not require repairs. The largest single group of voided maintenance actions could not be completed during the testing period because the part was not available or the required repair exceeded the permitted level of maintenance of the shop. When the data sheets were incomplete or in question for any reason, they were voided.

C. ANALYSIS OF THE DATA

1. TESTS MADE

a. A list of all the test made to insure the following statements can be found on page 1 in Appendix E.

b. An analysis of variance of the data at the .05 level indicated that the first level of work at Lemoore was the same as the first level at Miramar; that the second level of work at Lemoore was the same as the second level at Miramar; that the first level was significantly different from the second level for both installations and that difference of technicians and station were not sufficient to alter the results found. Therefore, it is possible to combine the results found at the two stations for the purpose of determing the basic level of work and errors.

c. The results of the second phase of the test using the JPA's indicated that a significant difference in time did exist between the experienced technicians using JPA's at Level I and experienced technicians not using JPA's at Level I. The experienced technicians took longer to perform similar work when using JPA's. At Level II the average time was slightly shorter for experienced technicians with JPA's than without them, but an analysis of variance indicated that no significant difference in time existed for Level II jobs using experienced technicians with and without JPA's. An analysis of variance of the .05 level indicated that no significant difference in time existed for inexperienced technicians using JPA's at Level I jobs and experienced technicians not using JPA's at Level I jobs.

d. No significant difference of time was found for Level II jobs between experienced technicians without JPA's and inexperienced technicians with JPA's.

e. Experienced technicians were slowed down by the use of the JPA's for simple short maintenance actions but provided error-free maintenance. They did not suffer any time penalty for Level II jobs when using JPA's. For inexperienced technicians, no loss in time, (no time penalty) was found for either Level I or Level II jobs.

D. ERRORS

1. DEFINITIONS

a. An error was noted for failure to "fix" a gripe, for any action that required the work be repeated, for an omission of a required action, for improper, unsafe actions (i.e., failure to disconnect the battery while working on electrical gear), crossing wires, not connecting parts properly, etc. It would seem probable that errors which occur are due to certain causal factors that could be determined and therefore with experience be reduced, if not eliminated. However, the large number of factors that can be responsible for errors and the null hypothesis of the lack of any specific treatment to reduce them provides a mathematical basis for assuming a regular distribution of the errors. If the two sample sets of observations have been drawn from a common binominal population in which the probablility of producing an error has not been changed, then the difference of the error population between the two samples will be small, and a test of significance is justified. A run test and a chi square test of the errors found in those non-scheduled maintenance actions that were only "Remove and Replace" indicated that no significant differences in the errors occurred. (The data and analysis is shown in Appendix E.)

b. The maintenance technicians using the standard manuals and those using the JPA's had the same percentage of errors in the maintenance actions observed. However, the only type of error that can be expected to be reduced by the use of JPA's would be those of omission of a required action and those due to the wrong step in some known required procedure. As noted previously, the normal Navy maintenance actions using the standard maintenance manual have no given standard steps. Therefore, only an error of omission can be called an error in procedure. Procedures that do not fix a gripe generally are due to the decision to do the wrong thing i.e., an error of decision.

c. Although the JPA's provided procedures, their use did not eliminate all errors. The subject did not always read the words that he scanned, i.e., after the second use, on simple jobs, the subjects tended to know what to do and therefore, although intending to read the directions would skip words. In one verified instance, the technician

did not "see" a sentence he was supposed to be reading. With use, the subjects tended to use the JPA's as a sort of guide, a sort of checklist. Although they were told to read and follow the JPA text, no formal requirement was made that they follow it word for word nor were they prevented from deviating from the text if they thought they were following it. As a result, it was noted that unless a specific order to follow the text accompanies the text under normal operations, and is checked, "use errors" will start to show up.

VII. CONCLUSIONS

A. EXPERIENCE

Experienced technicians doing Level I tasks suitable to JPA's in Phase II provided error-free maintenance. No significant difference in errors was found between any of the other phases and the standard operations, i.e., inexperienced technicians doing Level I, II, or III tasks made statistically as many errors as was normal for experienced technicians without the JPA's.

B. ERRORS

The results of the tests indicate that the errors were not altered by the manual used (with the exception noted); that the pretraining does not alter the use of the manual; that the time it takes to make a correct maintenance action is not a function of the manual, and that the difference between the manuals using JPA's and inexperienced men, and the standard manual plus experienced men, is of the same order as that of the stations and the men involved. The scatter in the data due to the subjects and station is at least as great as that due to the influence of the manual.

C. WORK OUTPUT

Based on the team system used in Phase III and extrapolating the results, the cost in manpower for four times the work load using new men would be five times the manpower. This is based on an inexperienced four-man team plus one experienced troubleshooter working as a unit. The data available does not indicate the number of inexperienced men that one qualified troubleshooter could keep gainfully active. During the test, no more than two men were ever required to be busy in one work center at any one time.

D. SIZE

The limiting size of the activity and the number of events that could be provided by such a system is not known. It was hoped that as the work load increased, as the number of events became sufficiently high, a limit would be reached and the system would bog down. In practice, due to conditions outside the test area, the number of maintenance actions at the test stations decreased by about 2/3 and at no time was that portion of the IMD involved in the maintenance of NC-8A's, required to operate at full capacity.

E. TRAINING

Although the technicians who can be used for maintenance do not require specialized schooling, the team system requires that the troubleshooter have specific experience with the gear being maintained. In fact, the demand on his skill is higher than that under the standard operation since all the work of his team passes through his hands.

VIII. APPENDICES

APPENDIX A

The following pages contain corrections and additions to the Job Performance Aids for the NC-8A Mobile Electric Power Plant. These errors and omissions were detected by the maintenance technicians during the "hands-on" validation phase of the test. It is significant that these errors and omissions were not detected during an earlier "desk-top" evaluation by the same technicians.

INDEX

Remove and Install Axle Housing
Vol. 2 - p. 112

Engine Speed, Electric Governor Control Adjustment
Vol. 3 - p. 255

Remove and Install Ring Gear Fly Wheel
Vol. 2 - p. 212

OMISSIONS

Wheel drum back plate and king pin
Cable Heads Rebuild
Fuel Level Sensing Unit
Starter Rebuild
Bolt sizes should be given
Cable Reel Rebuild
Removal and Installation of headlight boxes
Removal and Installation of Fuel Pressure Relief Valve

Vol. I
p. 13

Install Engine Panel (Corrected Procedure)

1. Place engine panel (1) at installed position
2. Connect Tachometer drive cable (5)
3. Connect Electrical Connector (3)
4. Connect wire bundle clamps (4)
5. Install screws (2)
6. Connect battery - Close hood.

p. 31

NOTE
Omit reference to "ether kit assembly Removal" and include the following steps

1. Remove ether bottle
2. Disconnect power lead
3. Disconnect ether line from engine

p.33

Remove Front Wheel Wells (Corrected Procedure)

1. Remove screws (4) holding air cleaner to fender
2. Remove screw (5) holding oil filter line to fender. ((5) located on top of right fender)
3. Remove 14 screws (3). Remove ten screws (1) Lift wheel well (2) from cart.

p. 33 & 34

Install Front Wheel Wells (Corrected Procedures)

1. Place wheel well (2) at installed position
2. Install screws (3) and (1)
3. Install screws (4)
4. Install screw (5)

NOTE

Omit reference to "Ether Kit Installation" and include:

1. Connect ether line to Engine
2. Connect power lead
3. Replace ether bottle

p. 53

Omission of cable clamp in cable REEL. Location: p. 53: Clamp holding cables (4) one or two inches from point of entry of cables into the REEL.

Also omitted in pages 54, 55, 57, 58, 59

p. 54 & 55

Remove Cable Reel Assembly

Addition to Step 3; Clamp (?) must be removed

Install Cable Reel Assembly

Addition to Step 3; Clamp (?) must be installed

p. 100

Remove and Install Rear Axle Assembly.

Supplies:

Container, one quart capacity.
Labeling Tape and pencil.

p. 102

Remove Rear Axle Assembly

5. Disconnect brake line (4) at end of copper line. Allow brake fluid to drain into a container. Cap or plug brakeline.
6. Disconnect flexible shaft (5) from right angle drive (6).

p. 103

5. Lower jack 14-15 inches
6. Step 7 p. 102
7. Lower Jack. Roll rear assembly (8) away from cart.

p. 104

Install Rear Axle Assembly (Corrected Procedure)

1. Roll rear axle assembly (7) under cart, using transmission jack under differential (6) raise axle assembly enough to allow wire to be connected.
2. Connect wire to propulsion motor. Remove labels.
3. Raise axle to installed position.

Step 2 becomes 4
Step 3 becomes 5
Step 4 becomes 6
Step 5 becomes 7

p. 105

1. Omit

Step 2 becomes 1
Step 3 becomes 2
Step 4 becomes 3
Step 5 becomes 4
Step 6 becomes 5

Vol II

p. 33 Remove and Install Fuel Tank

Personnel required: Two
Equipment Condition: Rear top panel must be removed. Vol. 1, p. 6

p. 35

10. Disconnect water drain line, located in the area of the fuel return line.

p. 37

5. Connect water drain line

NOTE

Rear Top panel must be installed not Fuel Tank cover.

p. 69

TEST GOVERNOR ACTUATOR

Special Tools and Test Equipment:
Regulated fuel supply 30-100 psi and variable D.C. power supply:

Neither of these test equipment are readily available in the shops. Therefore, Test procedure in p. 78 and 79 cannot be performed.

Procedure for adjustment, after it has been in the Unit, should be as follows:

1. Back off adjustment screws
2. Start unit
3. Hold actuator to maintain idle at 1000 RPM
4. Rotate mode selector to "off" position. Maintain engine idle manually (push rod)
5. Screw in adjustment screw until unit dies down
6. Tighten Lock nut.

p. 91

Install Batteries

Omission:

- Instruction on cleaning leads
- Instruction on proper battery polarity installation
- Warning to make sure that hood prop bar does not touch leads, as they will wear out.

p. 108

Remove and Install Starter Motor

Equipment Condition

Right front wheel well must be removed. Vol. I, p. 31
Battery must be disconnected.

p. 110

Remove Starter Motor

1. Disconnect wires from starter solenoid (1).

p. 111

Install Starter Motor

3. Connect wires to starter solenoid (1).

p. 113

Omission:

Removal and Installation of solenoid

p. 114

NOTE

Right front wheel well must be installed.
Vol. 1, p. 33
Battery must be connected.

p. 146

Install and Replace Oil Filter Assembly

Omission: Picture should show gasket between stud (Refer to #7, p. 149) and body of Oil Filter Assembly.

p. 149

Service Oil Filter Assembly

4. Inspect gasket (?). Remove and replace if marked.

Step 4 becomes 5
Step 5 becomes 6
Step 6 becomes 7
Step 7 becomes 8
Step 8 becomes 9
Step 9 becomes 10

p. 214

Remove Fly Wheel

2. Correction: Fly wheel is removed from crankshaft by removing two bolts under scuff plate.

Vol. III

In "Supplies:", Labeling tape and pencil must be included for every action in which wires must be disconnected and labeled. Tape and pencil are not readily available in the shops.

p. 69

Remove Governor Control Rheostats

Step 2 becomes 3
Step 3 becomes 2

p. 192

Remove and Install AC/DC Generator (Correction)

Equipment Condition:

Removal of Support bar (#6, p. 194) should take place before removal of Driver's side panel.

p. 194

1. Remove mounting bolts (7)
2. Label and disconnect cables from ground post (5)

p. 195

Omit Caution

1. Place wrench on bolt (NAVAIR 19-45-9, Figure 9-30, Item 160).
2. Remove drive disc bolts (1). Using wrench, rotate cooling fan (6) until remaining bolts can be removed. Remove all drive disc bolts.

p. 241

Remove Install and Test Accelerator Pedal Assembly (Correction)

Input Condition

Applicable Serial No. 311 and under
For 312 and over changes have been made and manual does not apply.

APPENDIX B

TYPES OF NON-SCHEDULED MAINTENANCE ACTIONS COVERED DURING THE JOB PERFORMANCE AIDS TEST PROGRAM

REMOVALS

AC Cables
AC/DC Generator
Accelerator Pedal Assembly
Batteries
Brake Shoes
Cable Reels
Cable Reel Light
Fly Wheel
Fuel Gage
Fuel Injectors
Fuel Pressure Relief Valve
Fuel Tank
Generator Disc Plate
Generator Panel
Governor
Master Cylinder
Parking Brake Cable
Rear Axle
Rear Top Panel
Ring Gear
Seat Support Assembly
Starter Motor Solenoid
Tachometer
Top Panel

REPLACEMENTS

AC Cables
AC/DC Generator
Accelerator Pedal Assembly
Batteries
Brake Shoes
Cable Reels
Cable Reel Light
Fly Wheel
Fuel Gauge
Fuel Injectors
Fuel Pressure Relief Valve
Generator Disc Plate
Generator Panel
Governor
Master Cylinder
Parking Brake Cable
Rear Axle
Rear Top Panel
Ring Gear
Seat Support Assembly
Starter Motor
Starter Motor Solenoid
Tachometer
Top Panel

ADJUSTMENTS

Brakes
Frequence (AC Output)
Governor
Governor Actuator
Idle Speed
Oil Pressure
Output Voltage
Overspeed
Parking Brakes
Wheel Alignment

REPAIRS

Accelerator Pedal
AC Switch
Cable Heads
Cable Reels
Fault Board
Fuel System (Drain, Bleed and Flush)
Governor Control Board
Head Lights
Mode Selector Switch
Oil Filter Assembly
Oil Leak
Rheostat Control Board
Traction Motor Terminal
Propulsion Circuit
Wiring Connections and Plugs

APPENDIX C

JOB FLOW DATA SHEETS

GLOSSARY

DOUBLE TOP)

DOUBLE BOTTOM) INDICATES TOUCH TIME COUNTS BETWEEN BARS

PROCESSING OR DECISION

MAN ENTERS

ACTION OR CONTROL OPERATION

TRANSMITTED INFORMATION

RECEIVED INFORMATION (VOICE OR WRITTEN)

RECEIVED INFORMATION (INDICATOR DISPLAY OR MACHINE OPERATION)

* TROUBLE SHOOTING

PREVIOUSLY STORED OR KNOWLEDGE FROM PAST

SINGLE LINED SYMBOL = MANUAL OPERATION

DOUBLE LINED SYMBOL = AUTOMATED OPERATION

P PANEL (UNCOVERED OR RETURNED)

QUARTER FILLED SYMBOL ¼ TIME NOT USED FOR OPERATION

HALF FILLED SYMBOL ½ TIME NOT USED FOR OPERATION

SOLID SYMBOL – INACTION – NO INFORMATION ACT

INDICATES REPAIR ACTIONS

T_R T_R = REMOVAL OF PART

INDICATES REPLACE ACTIONS

JOB CONTINUES (AT END)

START JOB

JOB IS CONTINUED (AT START)

STOP END OF JOB

PROCESS OR DECISION IS WRONG

T_1 PARTS

PROCESS OR DECISION IS CORRECT

T_2 TOOLS

T_3 LUNCH

T_5 JOB FINISHED OK CHECKED

T_i INSTALLS

Data Sheet Number

1-2	STD	Phase I	Water in fuel system
3	JPA	Phase II	Water in fuel system
4	JPA	Phase III	Oil leak-filter
5	STD	Phase I	Oil leak-filter
6	JPA	Phase III	Rack adjustment and filter
7	STD	Phase I	Rack adjustment
8-9	STD	Phase I	Bad starter
10-11	JPA	Phase II	Bad starter
12	JPA	Phase III	Bad starter
13-15	JPA	Phase II	Ring Gear Bad
16-20	STD	Phase I	Generator Bad
21-24	JPA	Phase II	Vibration excessive
25	JPA	Phase II	Overspeed
26-27	JPA	Phase III	Overspeed
28-29	STD	Phase I	Overspeed
30	STD	Phase I	Oil filter leak
31	JPA	Phase III	Oil filter leak
32	STD	Phase I	Emergency brake cable
33	STD	Phase I	Frequency meter
34	STD	Phase I	Propulsion Circuit
35	STD	Phase I	Shut off cable
36	STD	Phase I	No start
37-38	STD	Phase I	AC light on
39	JPA	Phase II	Starter
40-41	JPA	Phase II	Mode switch bad
42-44	JPA	Phase II	No propulsion
45-46	JPA	Phase II	Pulls to right
47	JPA	Phase III	Bad Mode selector
48	JPA	Phase III	Master cylinder broken
49	JPA	Phase III	Frequency Adjustment
50	JPA	Phase III	Under frequency
51-52	JPA	Phase III	Bad starter
53-54	JPA	Phase III	Generator bolt broken

DATA SHEET #1

The task performed under standard conditions. OSD actions are as follows: at 1244 the assigned technician received the task information from the work order; he assembled the necessary tools (9 minutes) and from 1254 to 1300 removed a component. He also received information and aid from another technician. Parts were obtained and repair action was followed by the requisition of parts again. The technician then continued repair action. Reinstallation commenced at 1344. At 1407 the technician left his own assigned task to assist on another job. For continuation see DATA SHEET #2.

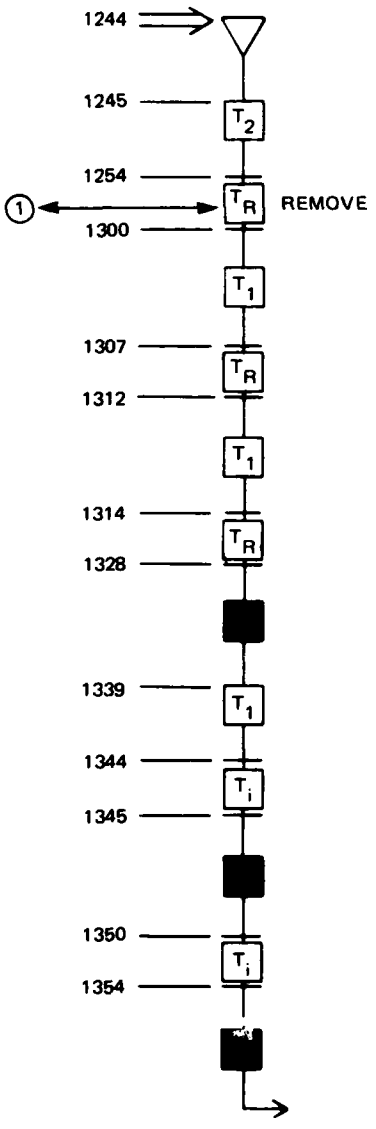
DATA SHEET 1
GROUP NUMBER II

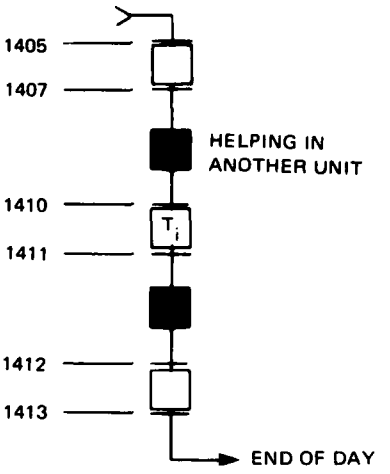
DATE: 20 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 183

FAULT LISTED: WATER IN FUEL SYST.
SPECIALIST E OR (M)
TASK LEVEL DETERMINED I (II) III
CODE 1 (2) 3 4

TIME START: 1244

OPERATOR NUMBER: 4





DATA SHEET #2

Continuation of DATA SHEET #1. The technician returned to his assigned task on the second day, making adjustments until 0812. Outside assistance was received from 0725-0727. Adjustment continued until 0812 with additional information received from 0805 to 0810. Installation action was taken from 0812 to 0823 and adjustments continued until 0834 (job end). Return of requisitioned tools at the job end was not part of "hands-on" work. For later comparisons it may well be noted here that this task was performed by a trained but slow worker performing a normal task in his own work center under standard conditions. In the performance of his work, outside assistance was required on three occasions (totalling approximately 8 minutes). This indicates 8 minutes of a second technician's productive time was required to complete this maintenance task.

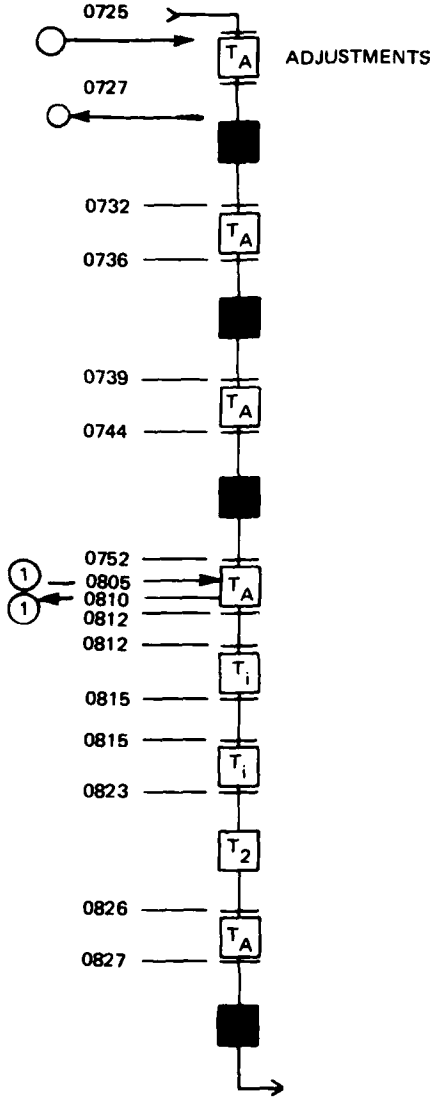
DATA SHEET 2
GROUP NUMBER II

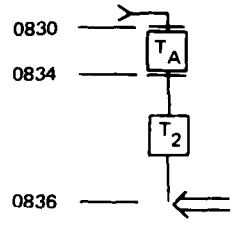
DATE: 21 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 183

FAULT LISTED: WATER IN FUEL SYST. (CONT.)
SPECIALIST E OR (M)
TASK LEVEL DETERMINED I II III
CODE 1 (2) 3 4

TIME START: 0725

OPERATOR NUMBER 4





DATA SHEET #3

This was a similar task to that of DATA SHEETS 1 and 2 but performed under JPA Phase II conditions. At the outset, technician is shown having prior knowledge (previous experience on same job) and making an error in a decision. Repair actions were performed until 0933 at which time the assigned technician reached an impasse and realized he was pursuing the wrong tactic. Information and physical assistance by a second technician was required for 11 minutes in a troubleshoot capacity. A new action was started at 1010 and continued to 1050. On checking the system it was noted that the unit did not work. A decision for proper corrective action was applied at 1053 followed by observed satisfactory operation. Task ended at 1057. This task was performed by a trained but slow technician with prior experience in this particular task. However, under JPA conditions, where procedures dictated by the JPA format were followed, the initial decision which was in error, led the technician down the wrong path until outside assistance was called in. This assistance produced the troubleshooting techniques, lacking in the JPA, that finally led to the proper solution of the problem. The JPA alone could not fulfill the necessary requirements of "troubleshooting."

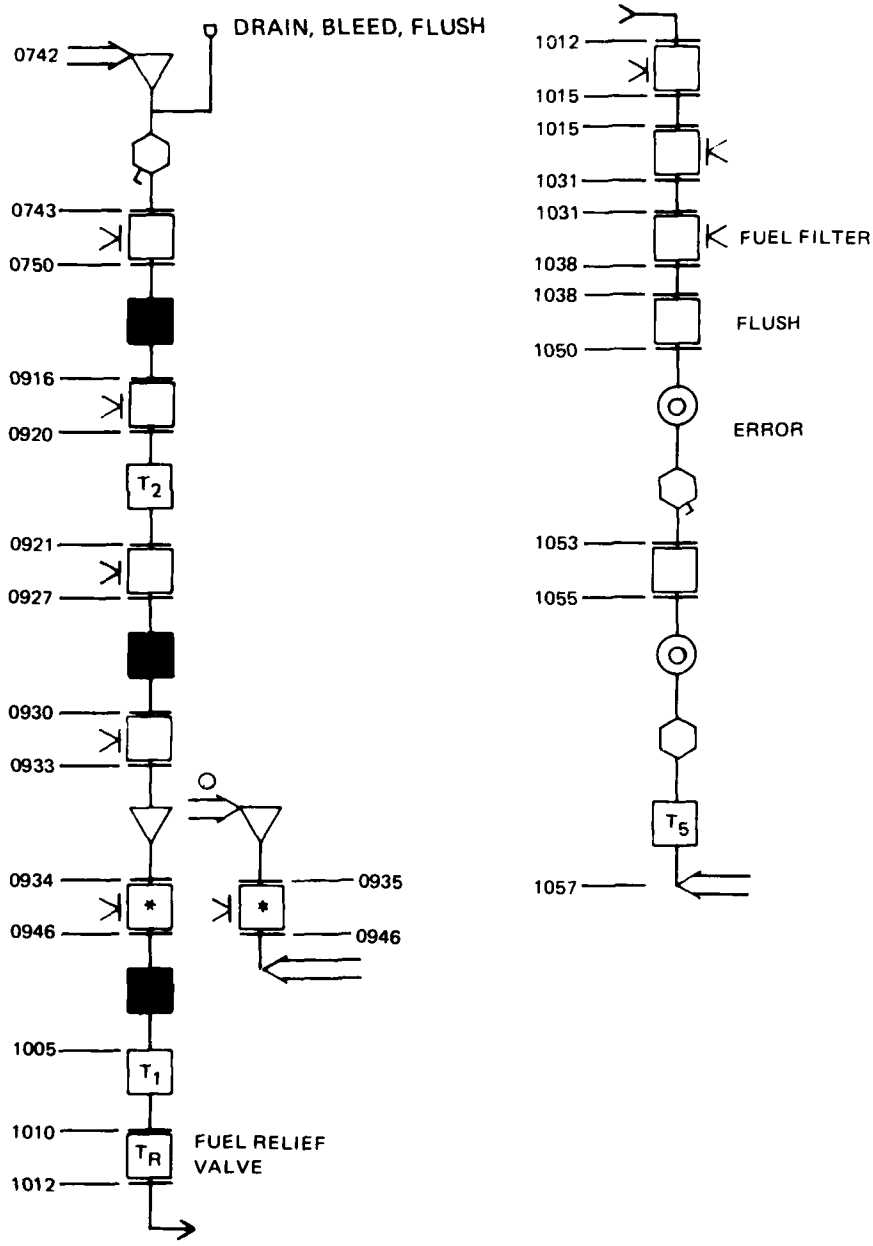
DATA SHEET 3
GROUP NUMBER I

DATE: 12 JULY '72
STATION: LEMOORE
SERIAL NUMBER: 215

FAULT LISTED: WATER IN FUEL
SPECIALIST E OR (M)
TASK LEVEL DETERMINED I (II) III
CODE 1(2) 3 4

TIME START: 0742

OPERATOR NUMBER: 4



DATA SHEET #4

The task was performed under JPA Phase III conditions by an untrained technician. In this procedure, trouble-shooting was performed by one designated technician and the course of action directed. The JPA format was followed step-by-step to a satisfactory conclusion. Momentary assistance by the troubleshooter - technician was required regarding a special tool. With troubleshooting performed by others and a direct course of action prescribed, an error-free job was performed by an untrained technician in 30 minutes following the JPA format.

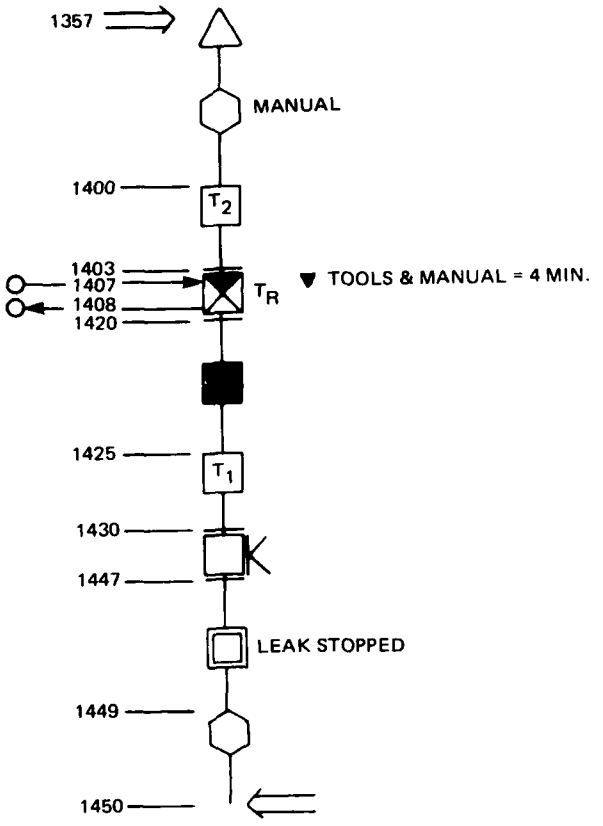
DATA SHEET 4
GROUP NUMBER III

DATE: 7 AUGUST '72
STATION: LEMOORE
SERIAL NUMBER: 267

FAULT LISTED: OIL FILTER LEAK
SPECIALIST (E) OR M
TASK LEVEL DETERMINED (I) II III
CODE 1 2 3 4

TIME START: 1345

OPERATOR NUMBER: 4



DATA SHEET #5

The task was performed under standard conditions by an experienced technician. This task is similar in nature to that of DATA SHEET #4. The experienced man in this case handled his own troubleshooting, determined his course of action and completed an error-free task in 2 minutes.

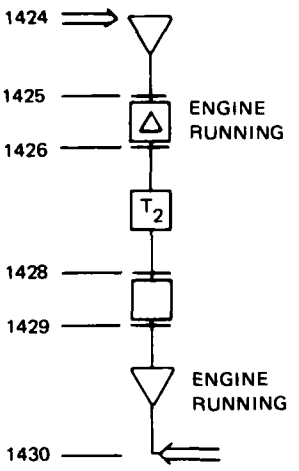
DATA SHEET 5
GROUP NUMBER II

DATE: 27 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 178

FAULT LISTED: OIL FILTER LEAKS
SPECIALIST E OR (M)
TASK LEVEL DETERMINED (I) II III
CODE (1) 2 3 4

TIME START: 1424

OPERATOR NUMBER: 1



DATA SHEET #6

This task was performed under JPA Phase III conditions by an untrained technician and a helper. The JPA format calls for assistance for component removal action and injector adjustments. At 1345, an outside technician transmitted information for the two-man task.

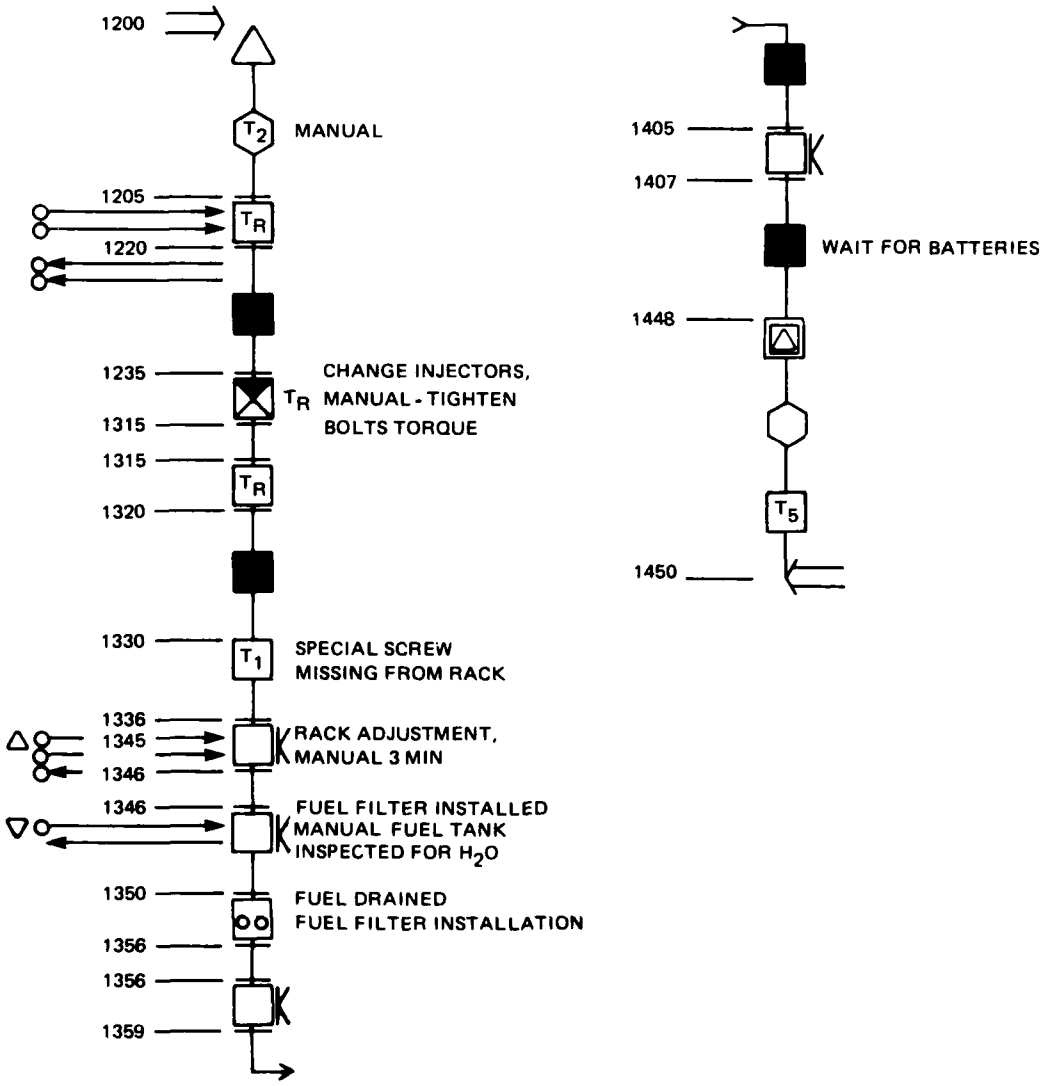
DATA SHEET 6
GROUP NUMBER III

DATE: 17 AUGUST '72
STATION: LEMOORE
SERIAL NUMBER: 195

FAULT LISTED: BAD FUEL INJECTORS
SPECIALIST (E) OR M
TASK LEVEL DETERMINED (I) II III
CODE 1 2 3 4

TIME START: 1200

OPERATOR NUMBER 3



DATA SHEET #7

The task performed under standard conditions by a trained technician. This task was similar to that of DATA SHEET #6. The technician made a decision which was at fault and resulted in wasted time and effort until 1349. At 1349 troubleshooting disclosed the true fault which was corrected in 13 minutes.

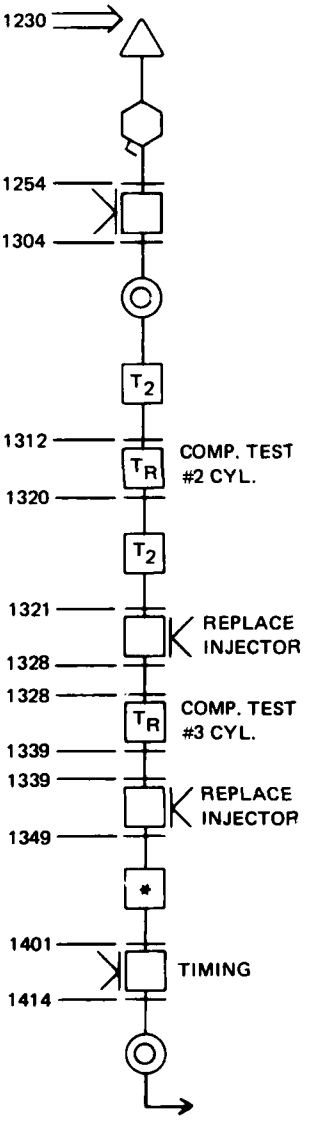
DATA SHEET 7
GROUP NUMBER I

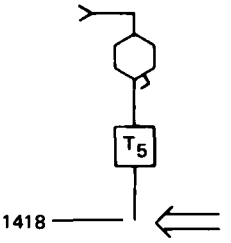
DATE: 20 JULY '72
STATION: LEMOORE
SERIAL NUMBER: 087

FAULT LISTED: RACK ADJUSTMENT
SPECIALIST E OR (M)
TASK LEVEL DETERMINED I (II) III
CODE (1) 2 3 4

TIME START: 1230

OPERATOR NUMBER; 1





DATA SHEET #8

This task was performed under standard conditions by a trained technician. Between approximately 0804 and 0815 another man joined the assigned technician for on-the-job training. The removal of the defective part was completed at 0824. No replacement part was available in stock and work stopped at 0825. For continuation see DATA SHEET #9.

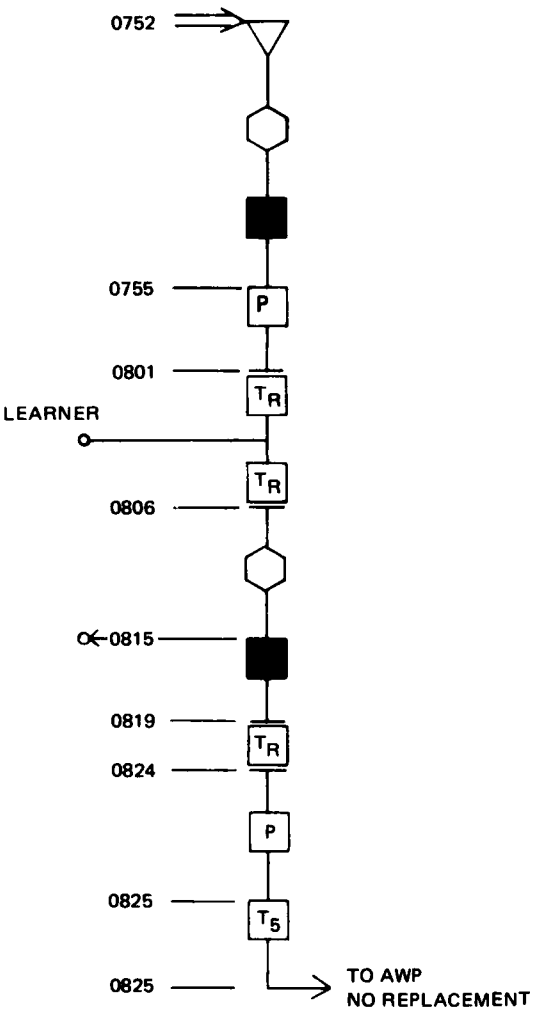
DATA SHEET 8
GROUP NUMBER II

DATE: 12 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 246

FAULT LISTED: WON'T START
SPECIALIST (E) OR M
TASK LEVEL DETERMINE: (I) II III
CODE (1) 2 3 4

TIME START: 0752

OPERATOR NUMBER 2



DATA SHEET #9

Continuation of DATA SHEET #8. The necessary replacement part was available on this date and continuation of the unfinished task was assigned to the same technician. OSD symbolism at 1246 indicates technician had prior knowledge of the task when making a decision regarding procedure. "Hands on" maintenance time ended at 1306. From that time to job end at 1438, panel replacement, test run, vehicle washing and "PM" (preventive maintenance) were performed.

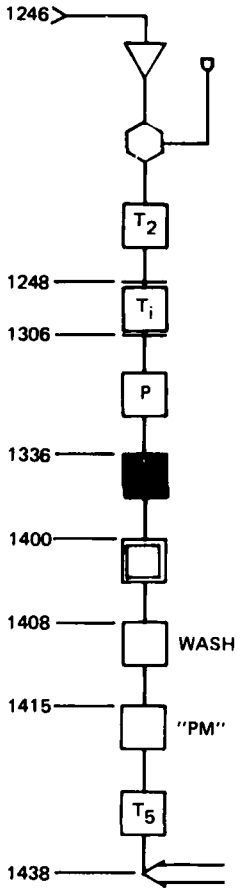
DATA SHEET 9
GROUP NUMBER II

DATE: 20 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 246

FAULT LISTED: WON'T START (Cont.)
SPECIALIST: (E) OR M
TASK LEVEL DETERMINED: (1) II III
CODE (1) 2 3 4

TIME START: 1240

OPERATOR NUMBER 2



DATA SHEET #10

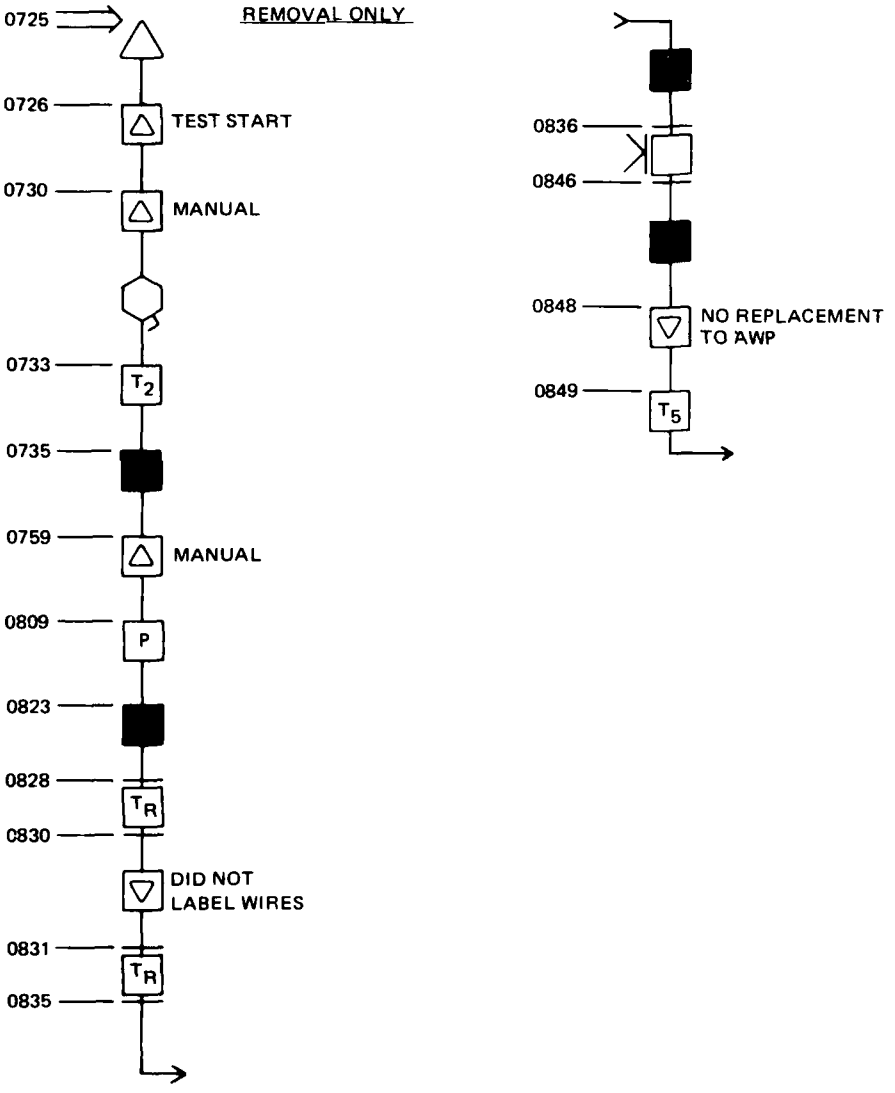
The task was performed under JPA Phase II conditions. The data recorded on DATA SHEETS 10 and 11 offer a comparison with an identical task previously recorded on DATA SHEETS 8 and 9. Work stopped on this unit also because replacement parts were not available.

DATA SHEET 10
GROUP NUMBER 1

DATE: 11 JULY '72
STATION: LEMOORE
SERIAL NUMBER: 261

FAULT LISTED: BAD STARTER
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I (II) III
CODE (1) 2 3 4

TIME START: 0725 OPERATOR NUMBER: 1



DATA SHEET #11

Continuation of DATA SHEET #10. Technician had prior knowledge of the task but was following the JPA format. Job-related information was received at 0812 and a fault logged against the technician for disregarding JPA directions. At 0848 a test run failed and outside information was required. Troubleshooting was necessary at this time since the JPA did not cover such contingency. Further installation actions and tests completed the task satisfactorily at 1013.

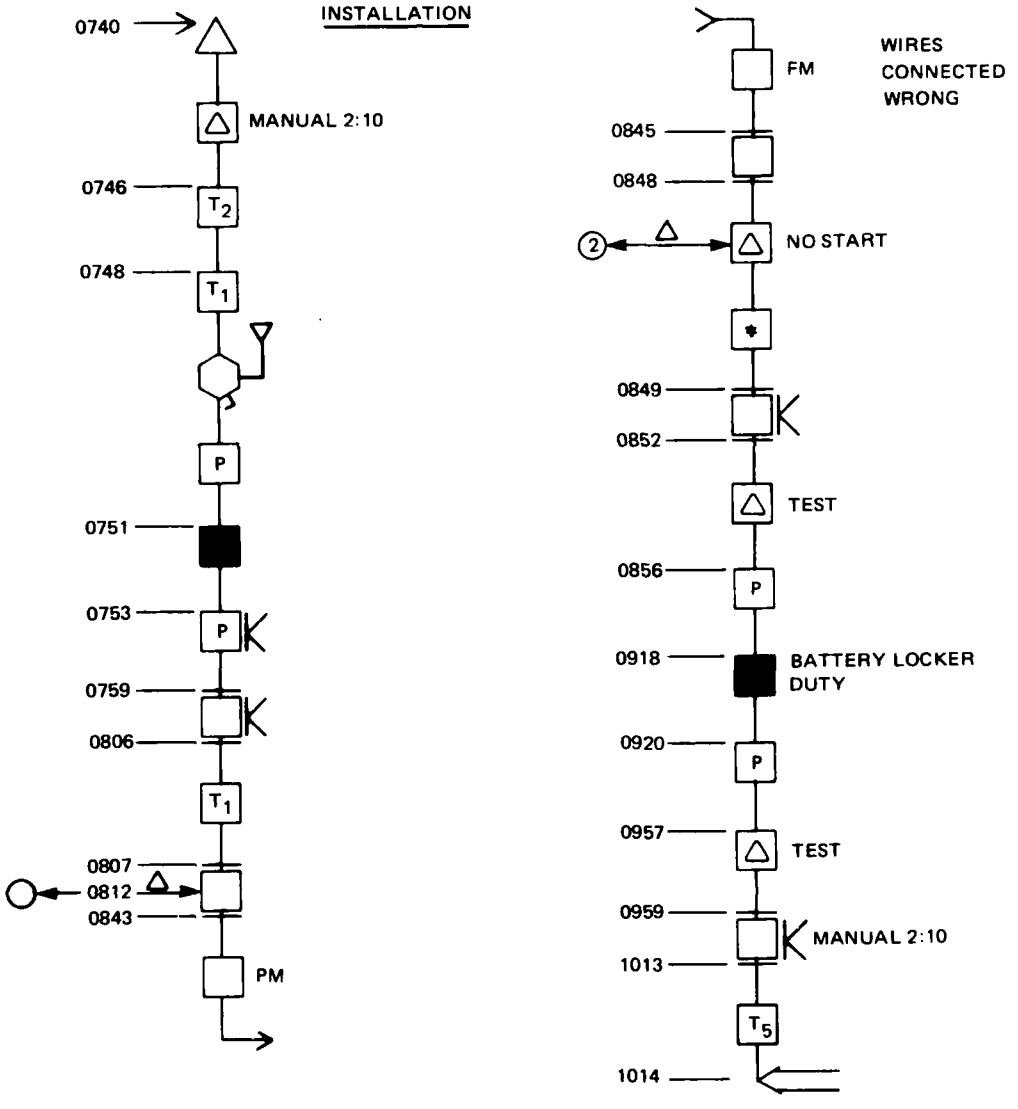
DATA SHEET 11
GROUP NUMBER I

DATE: 14 JULY '72
STATION: LEMOORE
SERIAL NUMBER: 261

FAULT LISTED: BAD STARTER (CONT.)
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I (II) III
CODE (1) 2 3 4

TIME START: 0740

OPERATOR NUMBER: 1



DATA SHEET #12

This task was performed under JPA Phase III conditions by an untrained technician. The task was removal and replacement of an electric starter motor and work procedures were particularly suited to a JPA format. In this task, a total of 10 minutes, 30 seconds times was spent in reading the JPA instructions, and a total of 52 minutes expended in actual "Hands on" maintenance time to produce a completed, error-free maintenance task by an untrained technician. Only momentary informational guidance was required at 1419 hours in addition to the JPA instructions being followed.

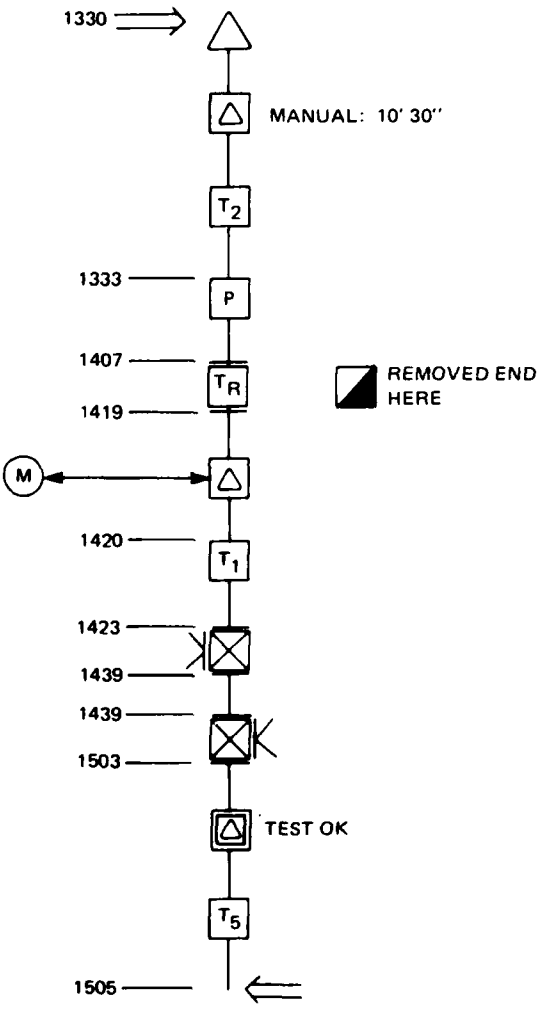
DATA SHEET 12
GROUP NUMBER III

DATE: 7 AUGUST '72
STATION: LEMOORE
SERIAL NUMBER: 244

FAULT LISTED: BAD STARTER
SPECIALIST E OR (M)
TASK LEVEL DETERMINED I (II) III
CODE 1 (2) 3 4

TIME START: 1330

OPERATOR NUMBER: 2



DATA SHEET #13

The job was performed under "JPA" conditions. Two technicians, having prior knowledge of the task procedure, received task information and performed a repair action not associated with the specific task (not "hands-on" time). Ten minutes was spent assembling tools followed by the removal of housing panels and the removal of the accelerator pedal for a total accountable "hands-on" time of 30 minutes. The job carried over to the next day. For continuation see DATA SHEET #14.

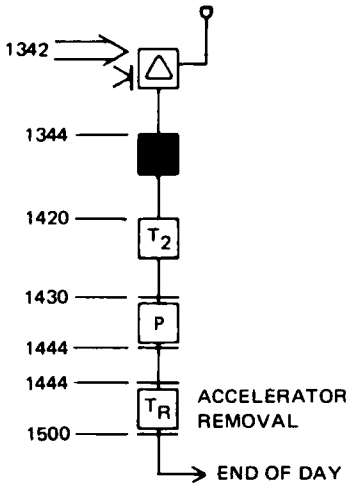
DATA SHEET 13
GROUP NUMBER VI

DATE: 18 JULY '72
STATION: QUONSET POINT
SERIAL NUMBER: 063

FAULT LISTED: CHANGE RING GEAR
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I II (III)
CODE 1 2 3 4

TIME START: 1342

OPERATOR NUMBER: 1 & 2



DATA SHEET #14

The previous day's work continued. The JPA was studied for procedure direction for 5 minutes followed by further panel removal and removal of various wires and cables. At 1230 the work day ended for the men involved and the job carried over to the next day. For continuation, see DATA SHEET #15.

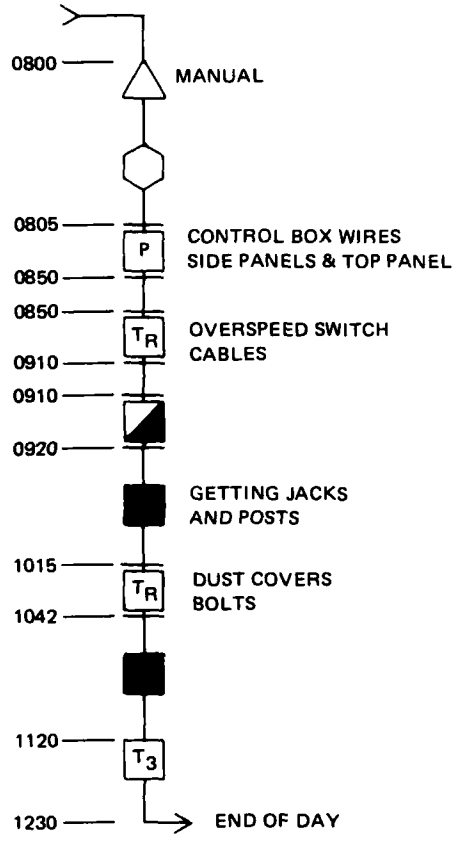
DATA SHEET 14
GROUP NUMBER VI

DATE: 19 JULY '72
STATION: QUONSET POINT
SERIAL NUMBER: 063

FAULT LISTED: CHANGE RING GEAR (CON'T)
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I II (III)
CODE 1 2 3 4

TIME START: 1342

OPERATOR NUMBER: 1 & 2



DATA SHEET #15

The previous day's work continued. The OSD shows outside assistance by a 3rd man for 11 minutes (0819-0830). Following removal of the ring gear, repair action took place for 41 minutes. At 0955 re-installation of the ring gear commenced and assistance of a third man was utilized to end of job. Task action was actually completed at 1510. However, under "load test" an engine fault was discovered and the entire unit was returned to the "down line" for later action by the mechanical work center.

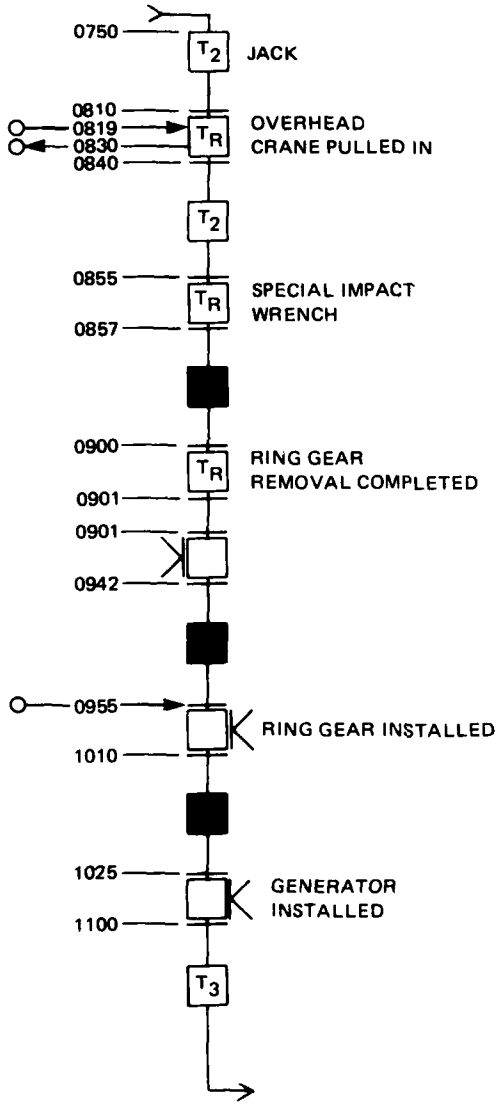
DATA SHEET 15
GROUP NUMBER VI

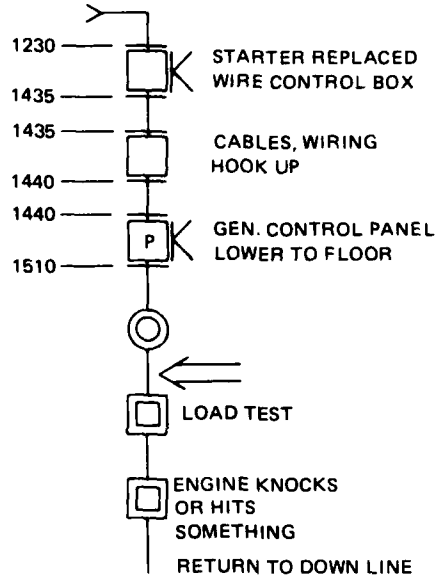
DATE: 20 JULY '72
STATION: LEMOORE
SERIAL NUMBER: 063

FAULT LISTED: CHANGE RING GEAR (CON'T)
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I II (III)
CODE 1 2 3 4

TIME START:

OPERATOR NUMBER: 1 & 2





DATA SHEET #16

This task consisted of removal of the AC/DC generator from one vehicle (#064) and installing it in another (#018). The task was performed under standard conditions. Job was assigned to technician #3 with an inexperienced man as "helper" (Tech #2). The OSD illustrate actions performed by technician #3 at the beginning of the task with intermittent assistance given him by #2 man (0718 to 0731, 1254 to 1259, 1305 to 1345). At 1252 a third man (Technician #1) assisted for 4 minutes and again, in company with a fourth helper momentarily at 1313. Work stopped on this task at 1345 and was resumed the following morning. It will be noted from the OSD in the right-hand column of the data sheet, that on the second day the "helper" (#2 man) performed much of the task action with the experienced man (#3) assisting. This interchange constituted "on-the-job-training" for #2 technician. For continuation, see DATA SHEET #17.

DATA SHEET 16
GROUP NUMBER I V

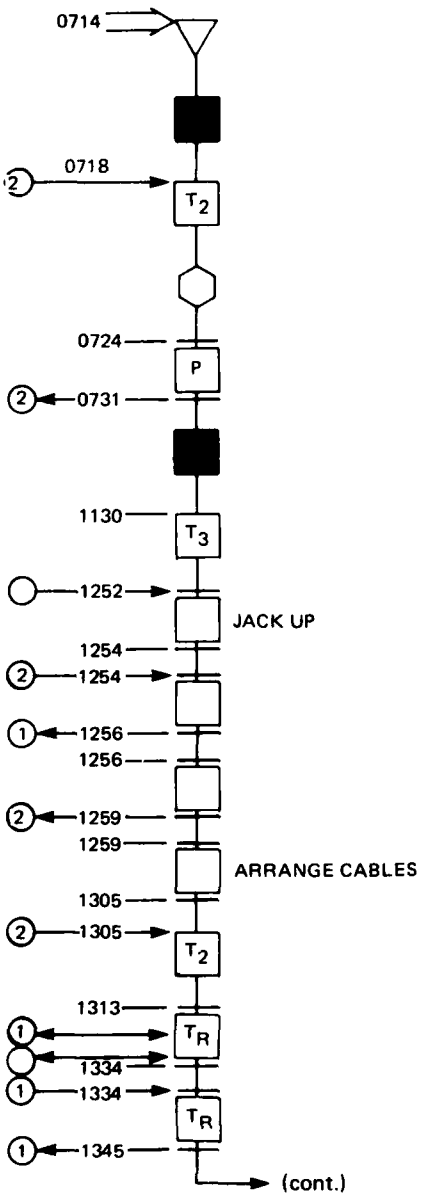
DATE: 19 JUNE '72
STATION: QUONSET POINT
SERIAL NUMBER: 064/018

FAULT LISTED: R&I GENERATOR
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I II (III)
CODE 1 2 3 4

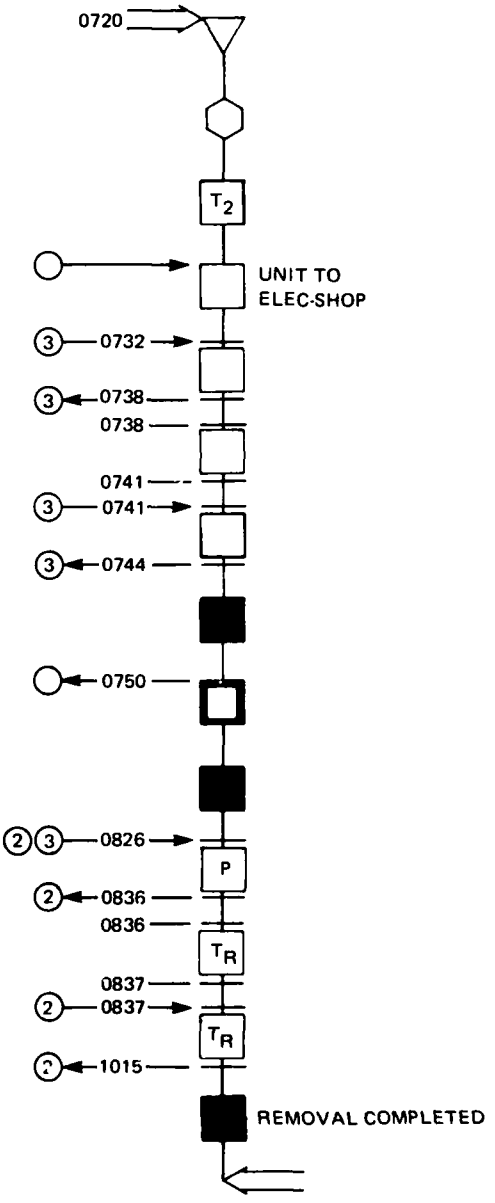
TIME START: 0714

OPERATOR NUMBER: 3 + 2

REMOVAL FROM 064



INSTALLATIONS IN 018



DATA SHEET #17

At 1345 work resumed in removal of components and was carried over to the next day. For continuation, see DATA SHEET #18.

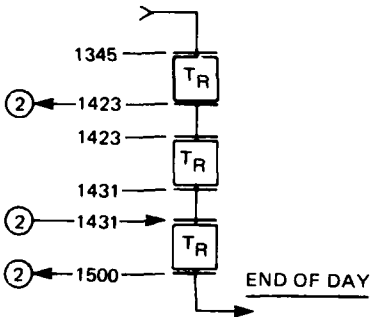
DATA SHEET 17
GROUP NUMBER IV

DATE: 19 JUNE '72
STATION: QUONSET POINT
SERIAL NUMBER: 018

FAULT LISTED: R & I GENERATOR (Cont.)
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I II (III)
CODE 1 2 3 4

TIME START: 0714

OPERATOR NUMBER: 3 + 2



DATA SHEET #18

Task continuation from DATA SHEET #17. This portion of the task consisted of installing the generator in unit #018 which was previously removed from unit #064. From 1235 to 1303 each man performed a separate part of the task: #2 technician installed controls while at the same time #3 man removed a component. Installation completed, unit was tested at 1306 and found to be faulty. Adjustments were made from 1315 to 1327 and work on the task was then stopped for the remainder of the day. For continuation see DATA SHEET #19.

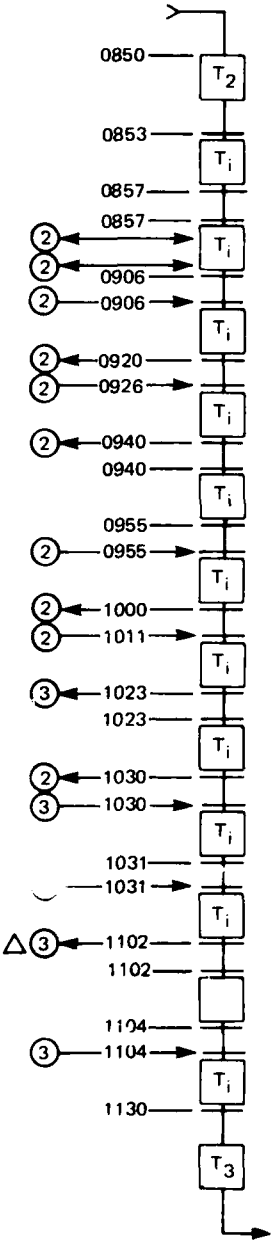
DATA SHEET 18
GROUP NUMBER IV

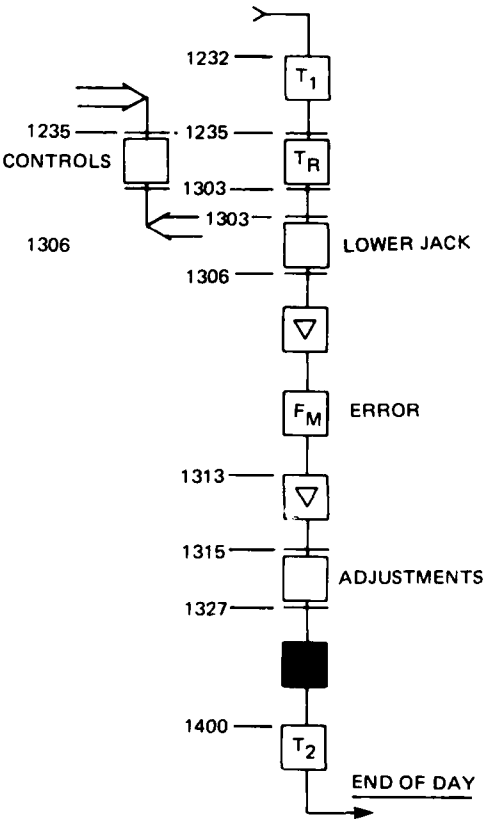
DATE: 20 JUNE '72
STATION: QUONSET POINT
SERIAL NUMBER: 018

FAULT LISTED: R&I GENERATOR (CONT.)
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I II (III)
CODE 1 2 3 4

TIME START: 0714

OPERATOR NUMBER: 3 + 2





DATA SHEET #19

Task continuation from previous day (DATA SHEET #18) No. 2 man was assigned to other tasks at this point and did not return to this job. At 1012, technician #3, handling this task alone, performed a test run of the equipment. Evidence of fire was noted and at 1036 the Shop Supervisor and technician #1 were called in. A second test was made and the unit was shut down. Following lunch, the assigned technician (#3), Shop Supervisor and technician #1 referred to the Standard Manual for guidance in troubleshooting. At 1336 work on the task was stopped. For continuation, see DATA SHEET #20.

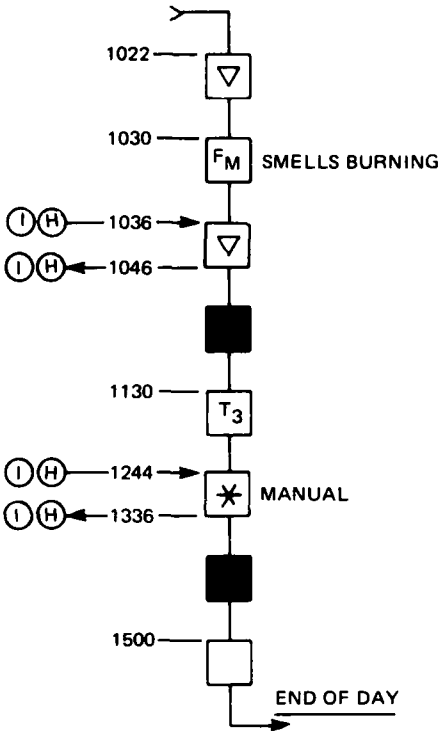
DATA SHEET 19
GROUP NUMBER IV

DATE: 21 JUNE '72
STATION: QUONSET POINT
SERIAL NUMBER: 018

FAULT LISTED: R&I GENERATOR (CONT.)
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I II (III)
CODE 1 2 3 4

TIME START: 0714

OPERATOR NUMBER: 3 + 2



DATA SHEET #20

Task continuation from DATA SHEET #19. Assistance was given by a technician in use of the Standard Manual from 0957 to 1018, and by technician #1 on two later occasions; physical assistance from 1035 to 1101, and information from 1303 to 1306. From 1306 no further work was performed this date. No further observations were made on this "incomplete task" because observer departed the activity for return to his home office. All actions performed in this 5-day period were "troubleshooting" procedures and were not conclusive.

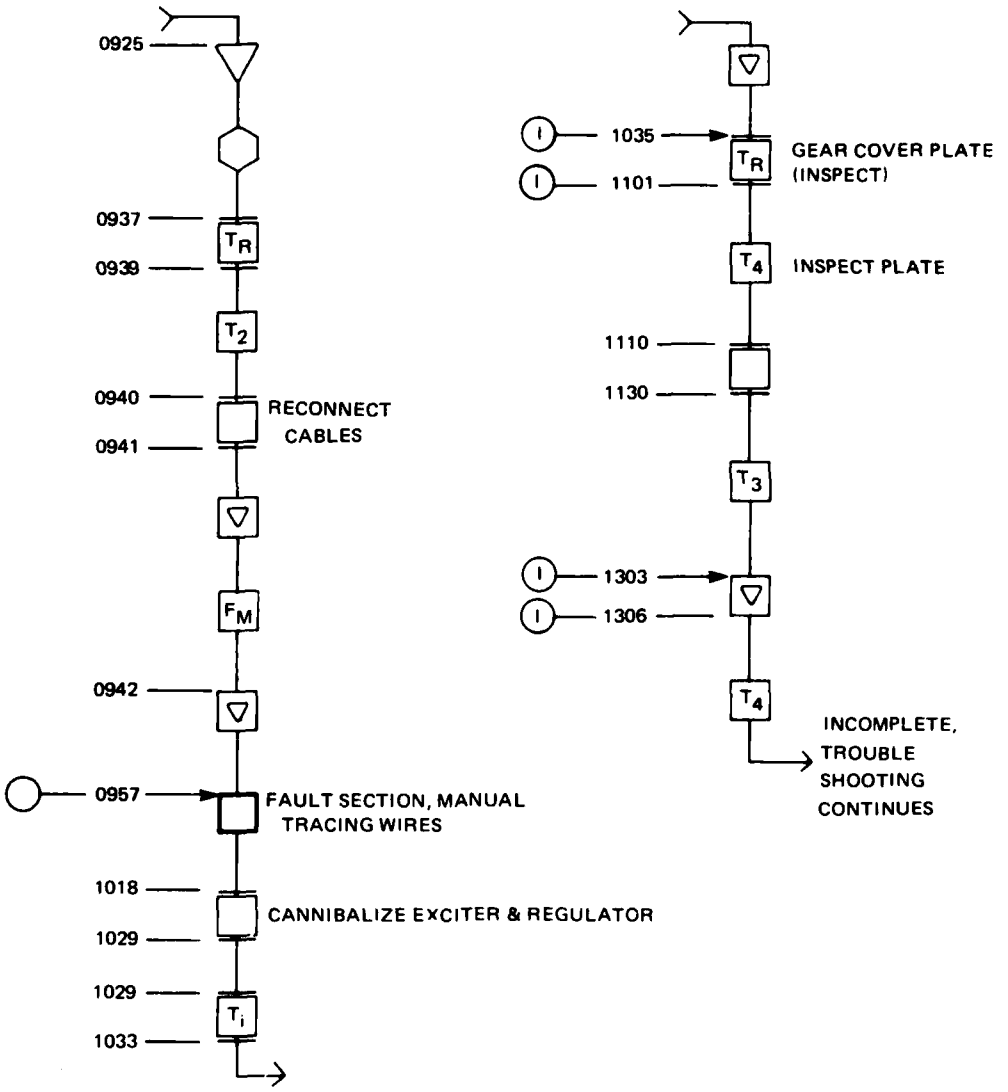
DATA SHEET 20
GROUP NUMBER IV

DATE: 22 JUNE '72
STATION: QUONSET POINT
SERIAL NUMBER: 018

FAULT LISTED: R & I GENERATOR (CONT.)
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I II (III)
CODE 1 2 3 4

TIME START:

OPERATOR NUMBER



DATA SHEET #21

This job was performed under JPA phase II conditions by 2 men (technician #1 assigned - #2 man as "helper"). Due to the nature of the fault, troubleshooting procedures dominated the first hours of work. Other than the two technicians assigned the task, six other technicians were involved at the start, observing and/or giving advice related to the problem at hand. Singly, in pairs and 7 men collectively became involved in an informational capacity until 1002, at which time a correct decision was made as to actual source of the fault and what corrective procedure to follow. For continuation, see DATA SHEET #22.

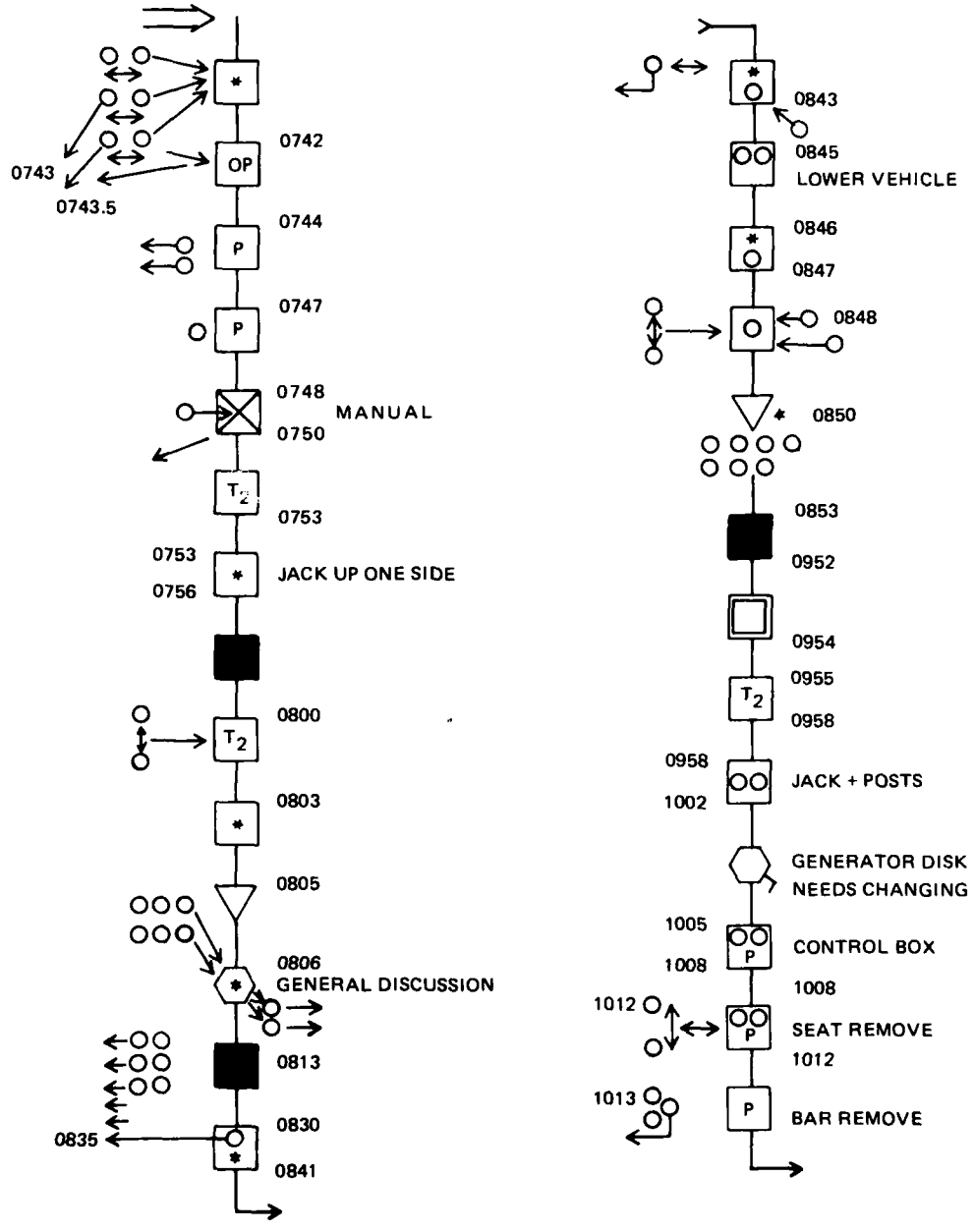
DATA SHEET 21
GROUP NUMBER V

DATE: 21 JULY '72
STATION: QUONSET POINT
SERIAL NUMBER: 034

FAULT LISTED: VIBRATION EXCESSIVE
SPECIALIST E OR M
TASK LEVEL DETERMINED I II (III)
CODE 1 (2) 3 4

TIME START: 0740

OPERATOR NUMBER; 1 + 2



DATA SHEET #22

The task continuation from Data Sheet #21. It is obvious from the OSD that continued interest of all shop technicians was prevalent throughout these task procedures, evidenced by the numerous in-and-out contacts by the entire shop group with the job. For continuation, see DATA SHEET #23.

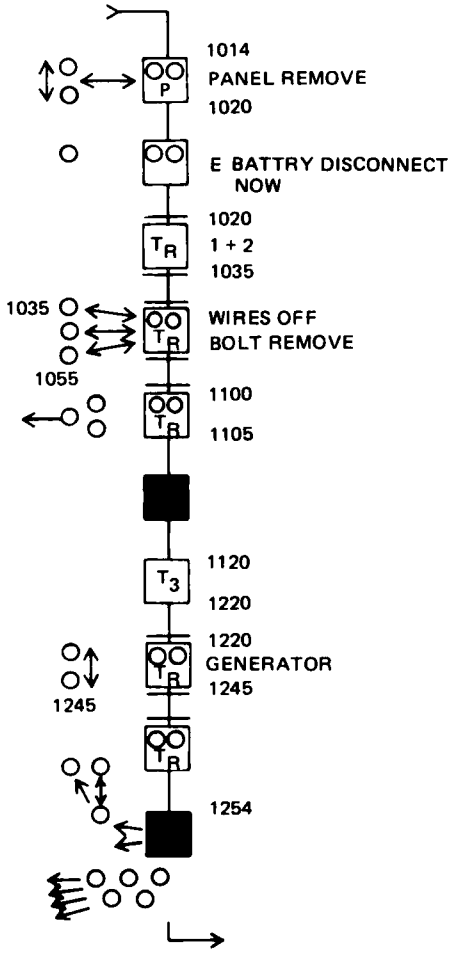
DATA SHEET 22
GROUP NUMBER V

DATE: 21 JULY '72
STATION: QUONSET POINT
SERIAL NUMBER: 034

FAULT LISTED: VIBRATION EXCESSIVE (Cont.)
SPECIALIST E OR M
TASK LEVEL DETERMINED I II (III)
CODE 1 (2) 3 4

TIME START:

OPERATOR NUMBER; 1 + 2



DATA SHEET #23

Continuation from Data Sheet #22. From 0742 to 1010, due to separate task actions by the two assigned technicians, separate OSD were used to illustrate each man's differing action times. However, commencing at 1016 to the end of the job, both technicians worked together on the same actions. At 1421 an interim test run was made and the original fault was found to be corrected. For continuation, see DATA SHEET #24.

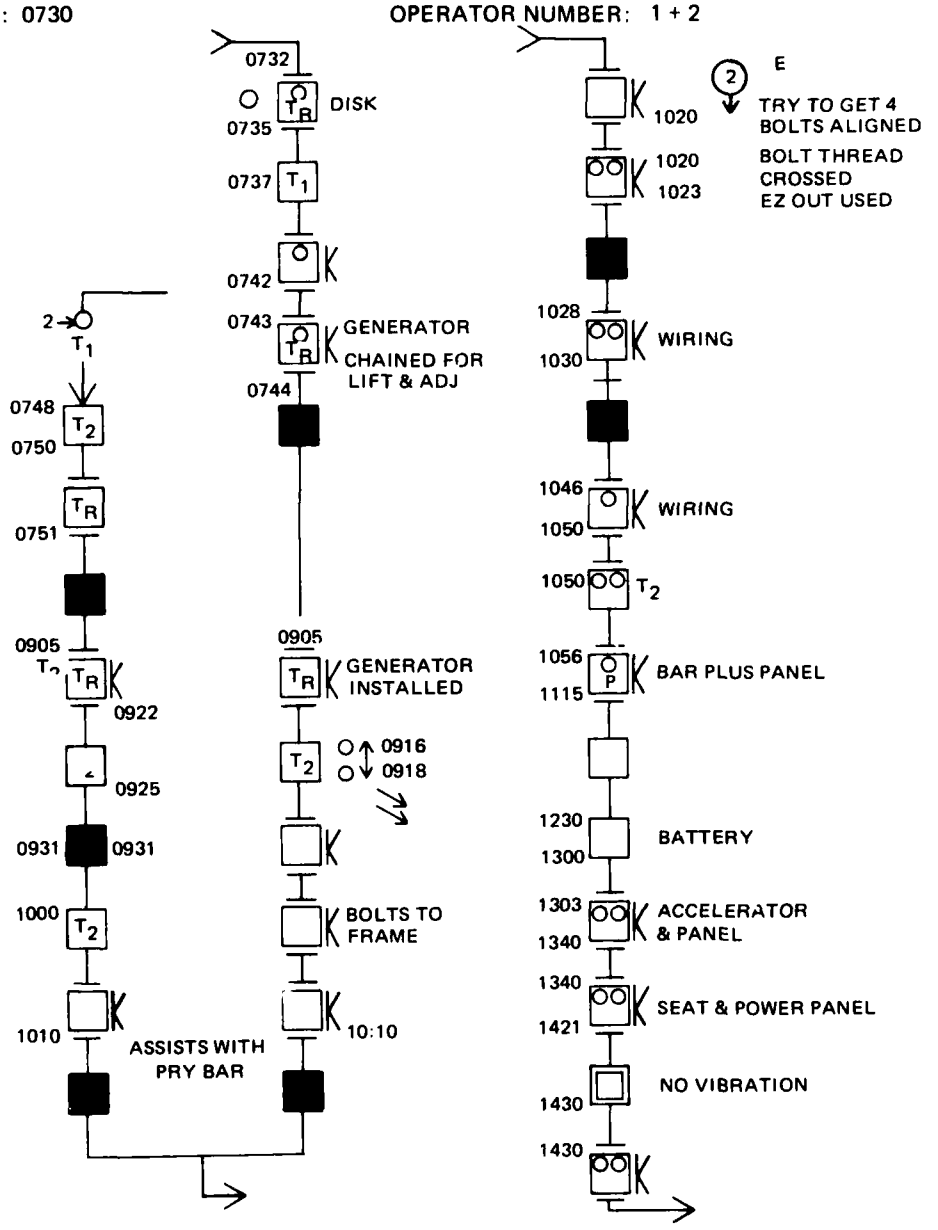
DATA SHEET 23
GROUP NUMBER V

DATE: 22 JULY '72
STATION: QUONSET POINT
SERIAL NUMBER: 034

FAULT LISTED: VIBRATION EXCESSIVE (CONT.)
SPECIALIST E OR M
TASK LEVEL DETERMINED I II (III)
CODE 1 (2) 3 4

TIME START: 0730

OPERATOR NUMBER: 1 + 2



DATA SHEET #24

Continued from DATA SHEET #23. At 1435 a test-run disclosed "no AC power output". Troubleshooting procedures were applied and an error in a corrective-action-decision was recorded. At 1446 the proper decision and action were observed and following a final test run, the job was completed at 1453. By its' nature, this 2-day task was unique in its' troubleshooting requirements and the involvement of all men in the work center.

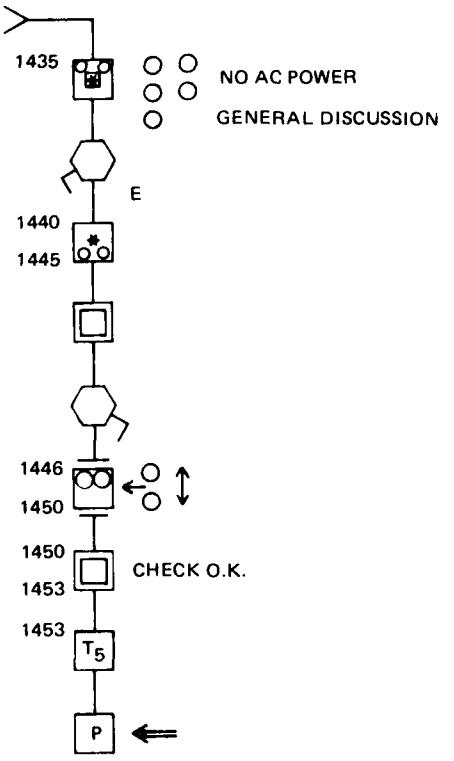
DATA SHEET 24
GROUP NUMBER V

DATE: 22 JULY '72
STATION: QUONSET POINT
SERIAL NUMBER: 034

FAULT LISTED: VIBRATION EXCESSIVE (CONT.)
SPECIALIST E OR M
TASK LEVEL DETERMINED I II (III)
CODE 1 (2) 3 4

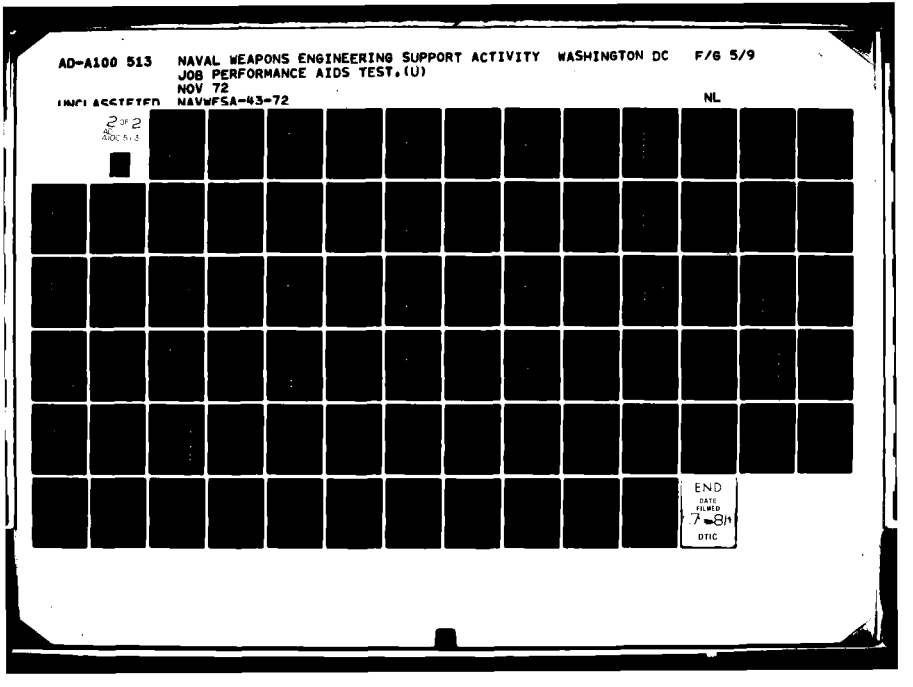
TIME START: 0730

OPERATOR NUMBER: 1 + 2



DATA SHEET #25

This task was performed under JPA conditions. Proper decision for corrective action was made at 0902. Repairs to accelerator switch were made without removing component from the vehicle. Repairs, followed by running tests, were made from 0905 to 0906 and again from 0921 to 0944. "Hands-on" maintenance action ended at 0942 and the job completed at 0953.


AD-A100 513
NAVAL WEAPONS ENGINEERING SUPPORT ACTIVITY WASHINGTON DC F/G 5/9
JOB PERFORMANCE AIDS TEST.(U)
NOV 72
NAVWESA-43-72
UNCLASSIFIED
NL
2 OF 2
AD
A100 513
END
DATE FILMED
7-81
DTIC

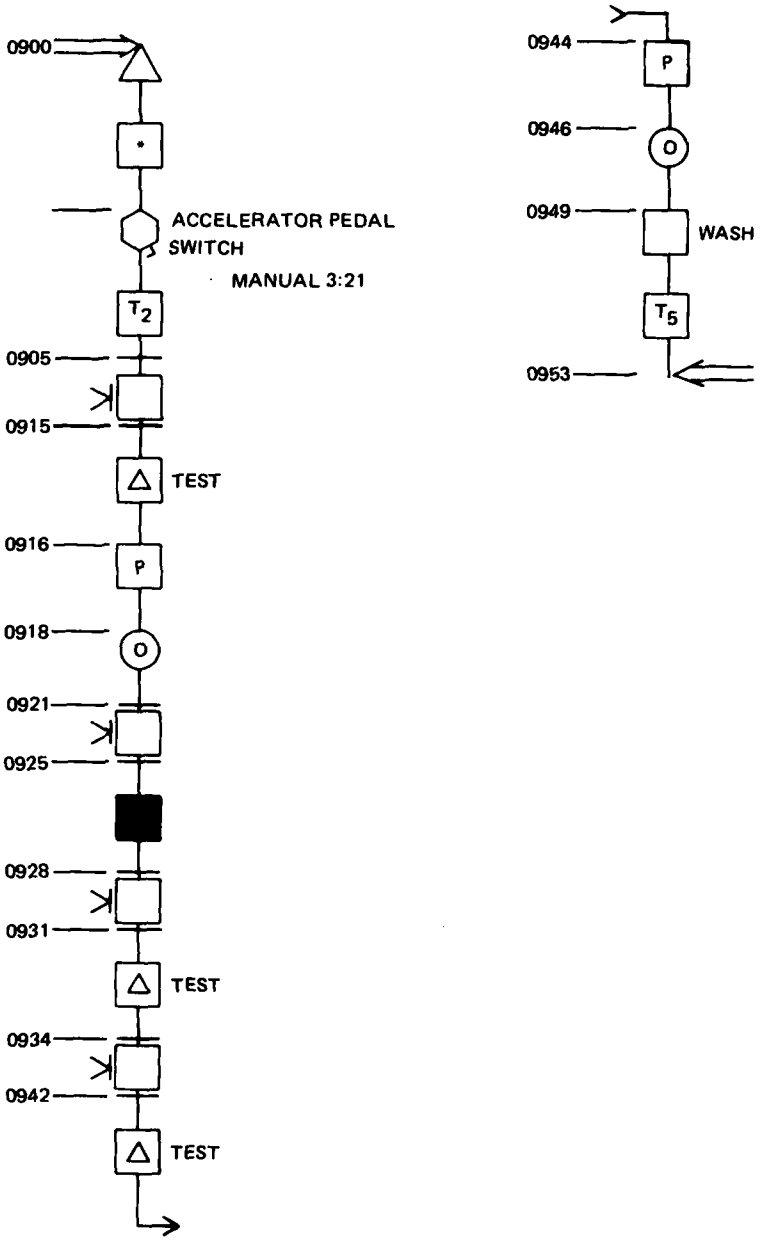
DATA SHEET 25
GROUP NUMBER 1

DATE: 21 JULY '72
STATION: LEMOORE
SERIAL NUMBER: 225

FAULT LISTED: OVERSPEEDS
SPECIALIST (E) OR M
TASK LEVEL DETERMINED (I) II III
CODE (1) 2 3 4

TIME START: 0990

OPERATOR NUMBER: 2



DATA SHEET #26

This task was performed under JPA phase III conditions. The task started with troubleshooter "M" and another technician giving the assigned technician information and instruction. Troubleshooting continued with the help of the "Shop CPO" (Chief Petty Officer) from 0909 to 0916 and the NAESU (Naval Aviation Engineering Service Unit) engineer from 0912 to 0918. At 0918 a correct decision was reached for corrective action. Symbolism of OSD from 0931 to 0939 indicates 75% of time recorded was actually "hands-on" time for removal of a component. At 0956 troubleshooter "M" gave momentary informational assistance only, and at 1018 troubleshooter "M" physically assisted #2 technician to completion of "hands-on" time, followed by a running test of the unit and job end.

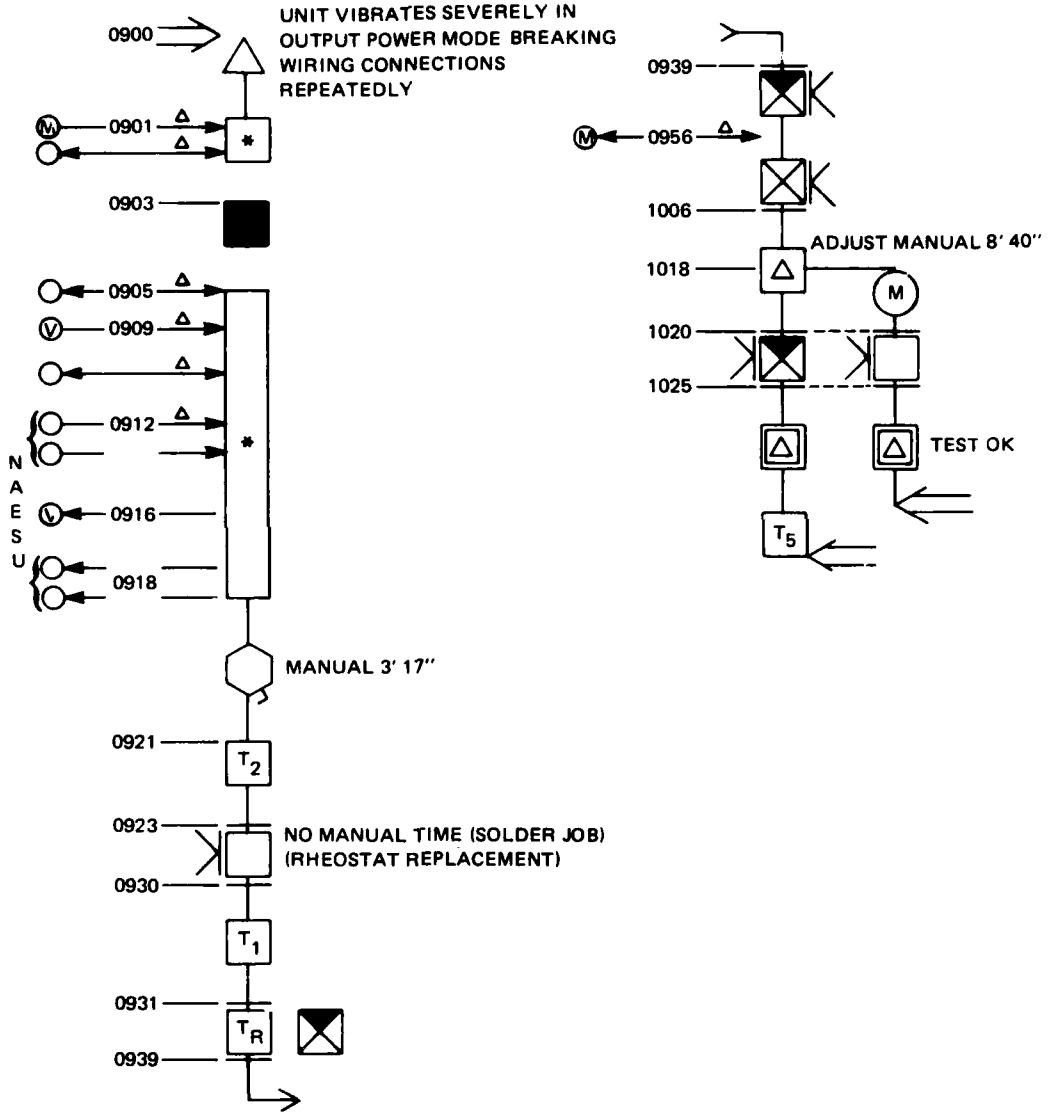
DATA SHEET 26
GROUP NUMBER III

DATE: 11 AUGUST '72
STATION: LEMOORE
SERIAL NUMBER: 170

FAULT LISTED: OVERSPEED
SPECIALIST E OR (M)
TASK LEVEL DETERMINED (I) II III
CODE 1 (2) 3 4

TIME START: 0900

OPERATOR NUMBER: 2



DATA SHEET #27

This job was performed under JPA phase III conditions. Fifteen minutes time was employed in troubleshooting and a correct action decision made at 0929. Informational assistance was given the assigned technician by the troubleshooter "M" and technician #1 from 0929 to 0934 and by the troubleshooter "M" at 0937 and 0946. Installation procedure from 0947 to 0951 shows "hands-on" time of 4 minutes of which 75% (or 3 minutes) was actual documented "hands-on" time. At 0951 troubleshooter "M" assisted the assigned technician for 2 minutes in conducting a "running test" which was not considered as "hands-on" time. Panel replacement at 0953 and "PM" at 0958 was also not recorded as "hands-on" time. Job completion was at 1000.

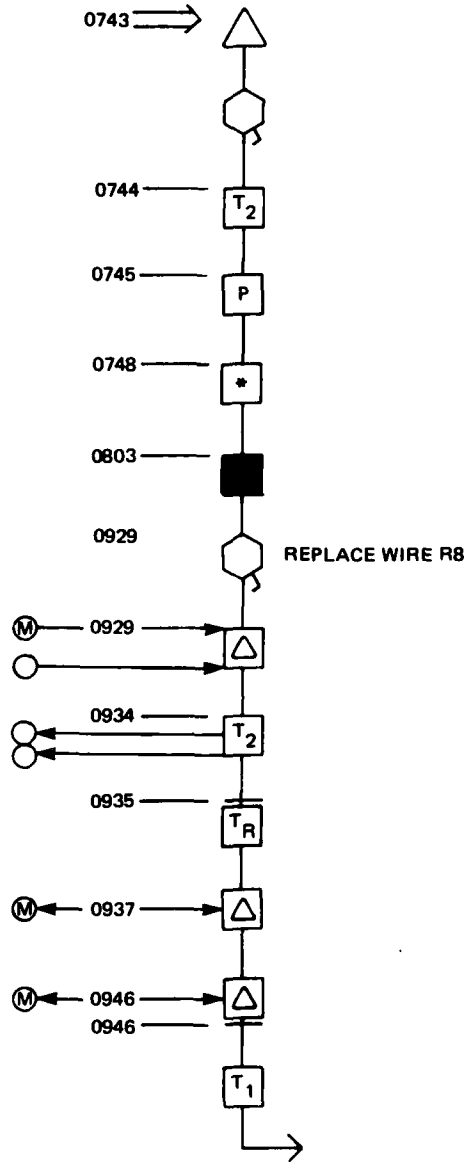
DATA SHEET 27
GROUP NUMBER III

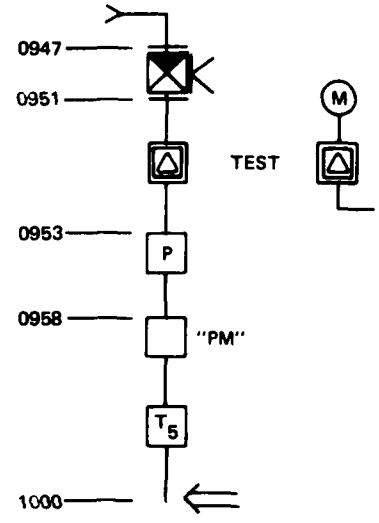
DATE: 14 AUGUST '72
STATION: LEMOORE
SERIAL NUMBER: 054

FAULT LISTED: OVERSPEED
SPECIALIST E OR (M)
TASK LEVEL DETERMINED (I) II III
CODE 1 (2) 3 4

TIME START: 0743

OPERATOR NUMBER: 1





DATA SHEET #28

This task was performed under standard conditions. Following information from "gripe ticket" (work order), troubleshooting evolved with use of the Standard Manual and information by a second technician on two occasions: 1318 and 1331. A running test was performed from 1342 to 1350. At 1350 the assigned technician left the job and did not return that day. For continuation, see DATA SHEET 29.

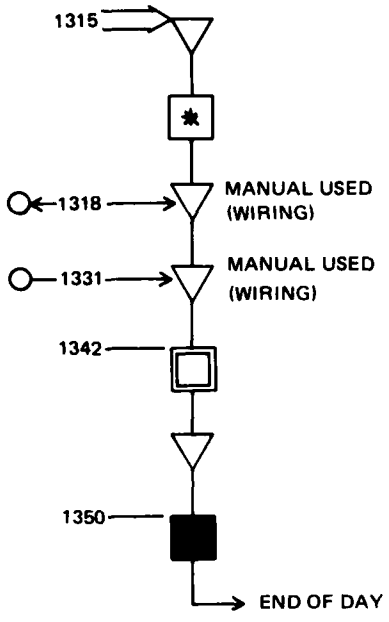
DATA SHEET 28
GROUP NUMBER II

DATE: 11 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 241

FAULT LISTED: OVERSPEED
SPECIALIST (E) OR M
TASK LEVEL DETERMINED: I (II) III
CODE: (1) 2 3 4

TIME START: 1315

OPERATOR NUMBER 3



DATA SHEET #29

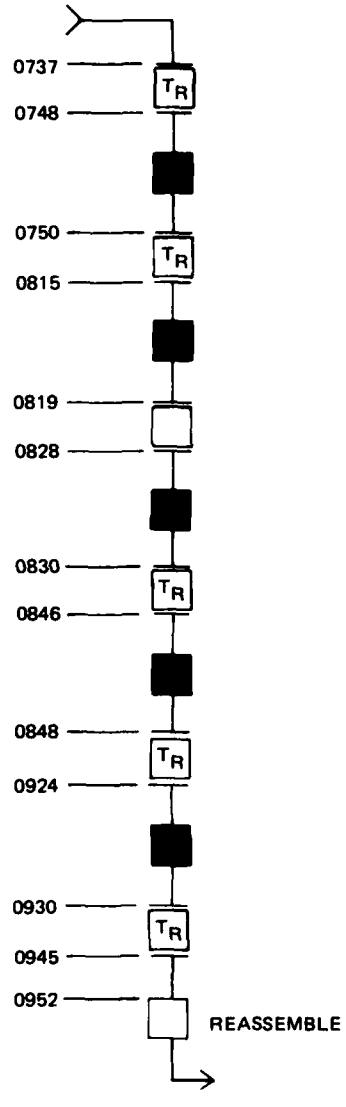
Continued from DATA SHEET #28. This job consisted of removal and repair of component wiring. Re-assembly and a running test checked O.K., and the job was completed at 0955.

DATA SHEET 29
GROUP NUMBER II

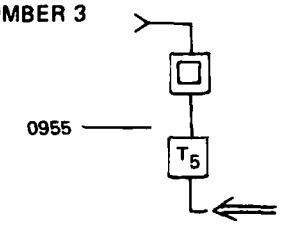
DATE: 12 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 241

FAULT LISTED: OVERSPEED (Cont.)
SPECIALIST: (E) OR M
TASK LEVEL DETERMINED I (II) III
CODE 1 (2) 3 4

TIME START 0737



OPERATION NUMBER 3



DATA SHEET #30

The task was performed under standard operating conditions. The assigned technician transmitted information pertinent to the task to another technician while assembling tools for the task. Maintenance action was performed from 0837 to 0854. A special tool was procured and removal of a component followed. After the time required to draw a part from the stock room, installation action consumed 4 additional minutes (0901-0905). Informational assistance was given by numerous technicians. At 0917 actual work was performed by another man while assigned technician returned special tools. At 0929 observation disclosed a completed task.

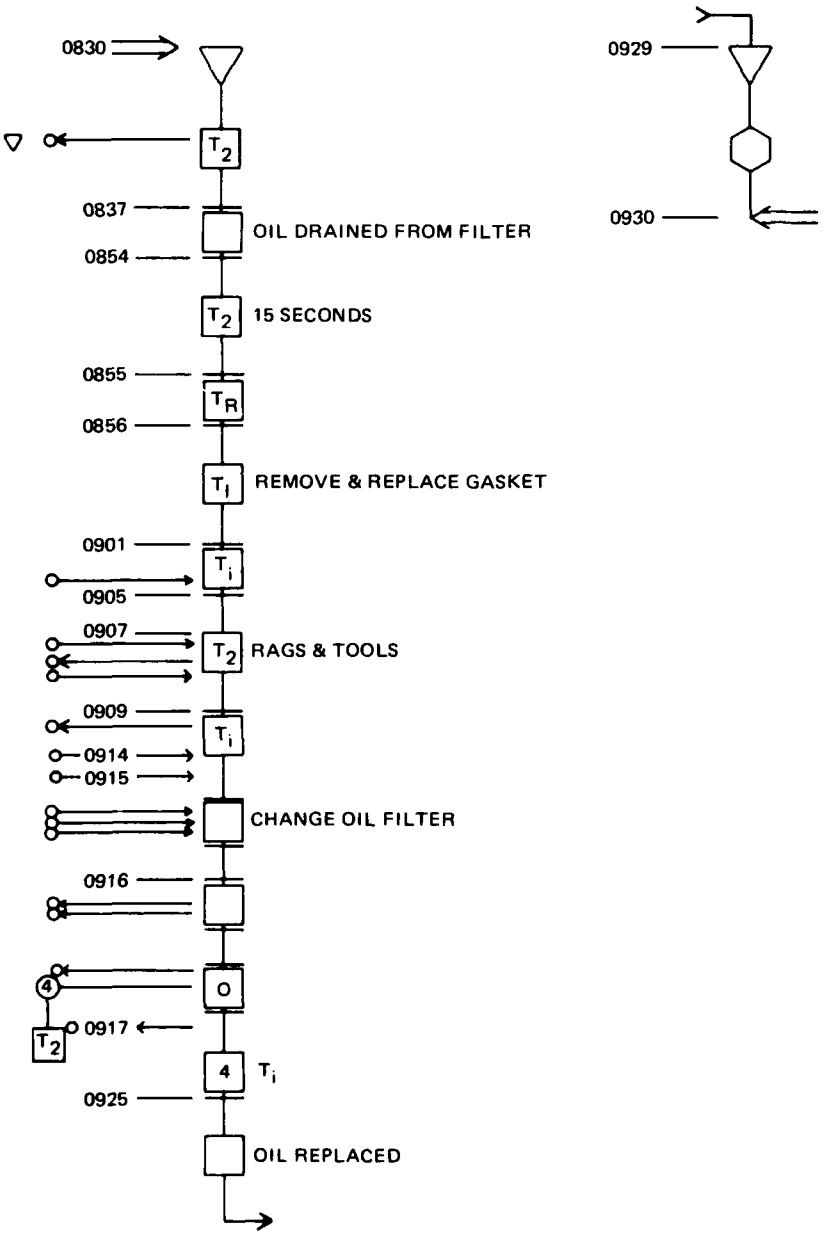
DATA SHEET 30
GROUP NUMBER II

DATE: 7 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 040

FAULT LISTED: OIL FILTER LEAK
SPECIALIST E OR (M)
TASK LEVEL DETERMINED (I) II III
CODE 1 (2) 3 4

TIME START: 0830

OPERATOR NUMBER: 4



DATA SHEET #31

This task was performed under JPA conditions. At 0942, symbolism shows a "work break" by the assigned technician. However, the second symbol "T_2" indicates man's time was actually spent requisitioning a special tool. It is obvious from the OSD that in the time between 1000 and 1023, a filter was installed, removed and installed a second time. The test run following 1023 put the oil filter under pressure as a final check and job was completed.

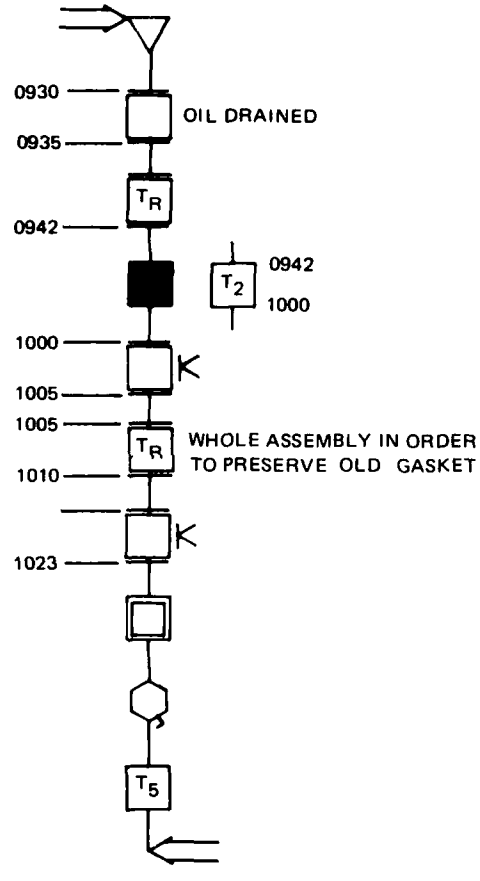
DATA SHEET 31
GROUP NUMBER II

DATE: 16 AUGUST '72
STATION: LEMOORE
SERIAL NUMBER: 267

FAULT LISTED: OIL FILTER LEAK
SPECIALIST: (E) OR M
TASK LEVEL DETERMINED: (I) II III
CODE 1 2 3 4

TIME START: 0930

OPERATOR NUMBER 3



DATA SHEET #32

This job was performed under standard conditions. OSD indicate verbal instruction was given the assigned technician at the start, followed in sequence by a procedure decision, repair action, part(s) requisitioning, repair action and special tool requisitioning. At 1033 parts installation commenced. At 1042 information or advice was received from an outside man and again at 1045. During continued installation, technician shorted the battery terminals and was charged with an error. Additional information was received from an outside man during this episode. Outside information was received again and a decision made that an incorrect part was being used. At 1055 lunch period commenced and at 1215 the correct part was requisitioned from stock room. During installation (1225-1235) outside information was again received for 8 minutes duration, followed by a test and the end of the job.

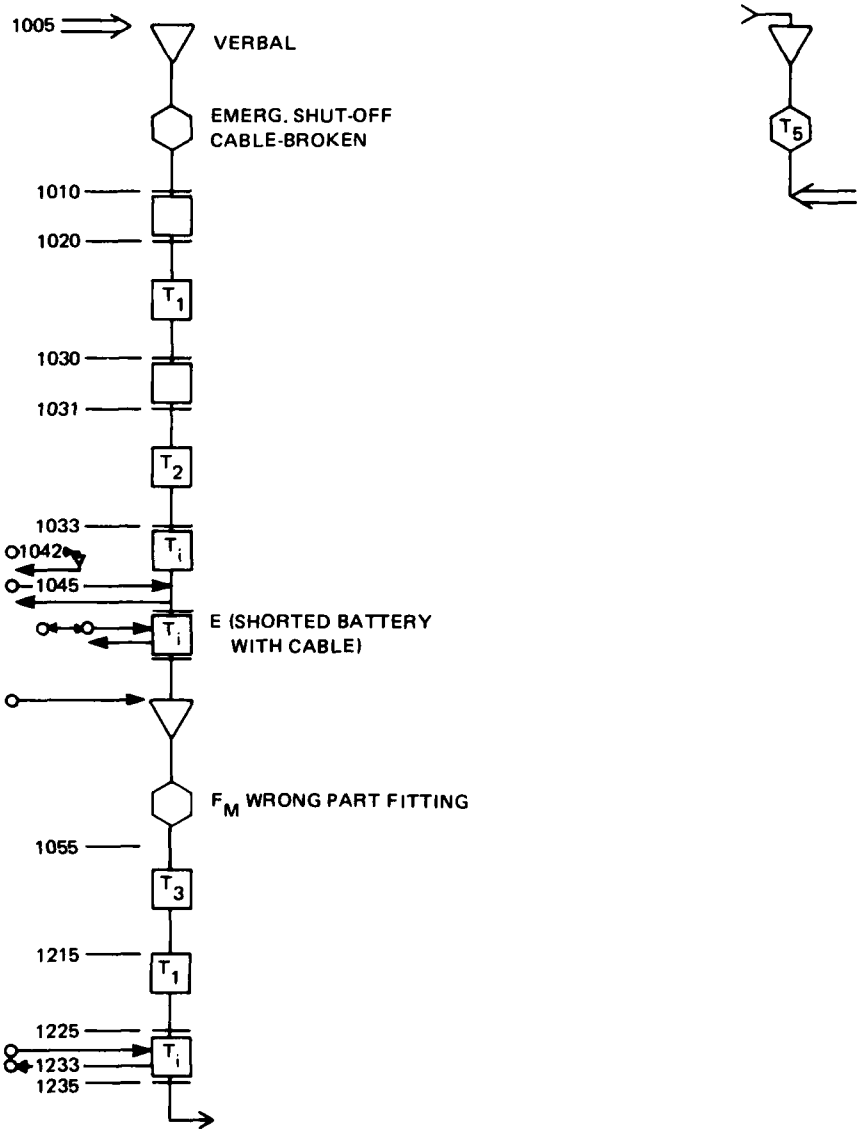
DATA SHEET 32
GROUP NUMBER II

DATE: 10 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 246

FAULT LISTED: EMERG. BRAKE CABLE BROKEN
SPECIALIST E OR (M)
TASK LEVEL DETERMINED (I) II III
CODE 1 2 3 4

TIME START: 1005

OPERATOR NUMBER: 2



DATA SHEET #33

The task was performed under standard conditions. Symbolism indicates "gripe" information was received at 1230 followed by an action procedure decision. Tools were assembled and the fault was located in 2 minutes (1233-1235). During component removal, outside assistance was received (1240-1250). Removal time was 14 minutes (1235-1249). No replacement part was available and a component was cannibalized from another unit. A maintenance fault occurred in the removal of the replacement part. The fault was not eliminated by the new part and an additional part was requisitioned and repair continued from 1313-1318. The unit was reassembled and tested and the job completed at 1328.

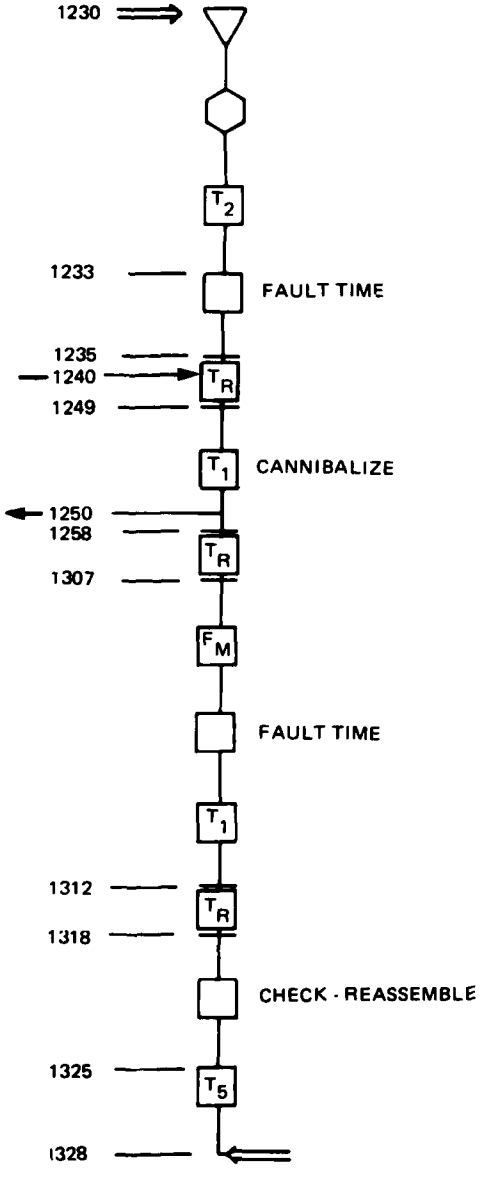
DATA SHEET 33
GROUP NUMBER II

DATE: 12 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 682

FAULT LISTED: FREQ. METER INOPERATIVE
SPECIALIST (E) OR M
TASK LEVEL DETERMINED (I) II III
CODE (1) 2 3 4

TIME START: 1230

OPERATOR NUMBER: 2



DATA SHEET #34

This task was performed under standard conditions. OSD illustrate 4 minutes was spent in locating the fault. During this time, information was received from another man and reference to the wiring diagrams in the Standard Manual was made on 2 occasions. Component removal and repair took 1 hour 10 minutes (0946-1056). At 1213 the re-installation started and required 33 minutes. The unit was tested, and the job completed at 1310.

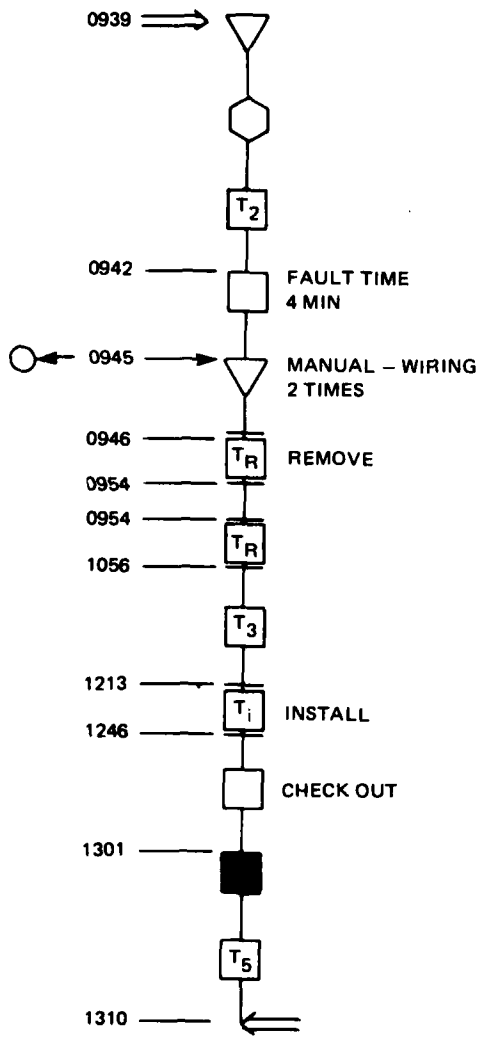
DATA SHEET 34
GROUP NUMBER II

DATE: 20 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 054

FAULT LISTED: PROPULSION CIRCUIT BAD
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I (II) III
CODE 1 (2) 3 4

TIME START: 0939

OPERATOR NUMBER 4



DATA SHEET #35

The job was performed under standard conditions. The technician was informed of the task at 1028. The removal of the broken part took 3 minutes. The installation (19 minutes) was finished by 1225. However, a fault in the installation was noted and additional work from 1235 to 1242 was required to finish the job. The job was completed at 1246.

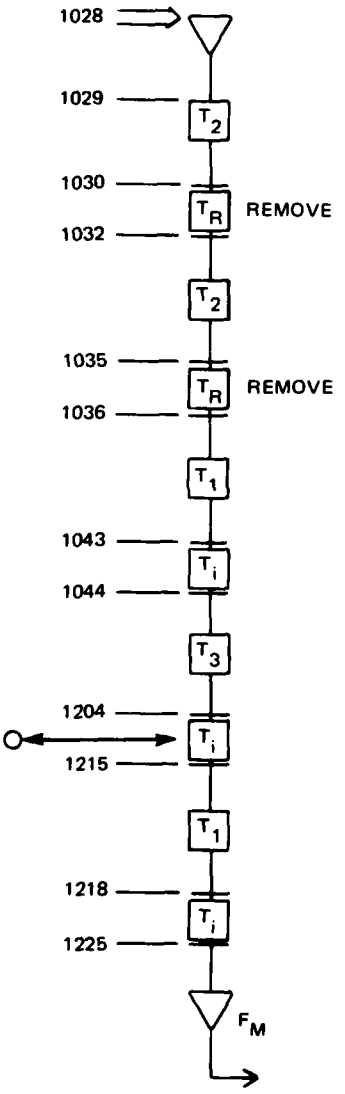
DATA SHEET 35
GROUP NUMBER II

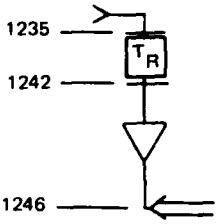
DATE: 18 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 703

FAULT LISTED: EMERG. SHUT-OFF CABLE BROKEN
SPECIALIST E OR (M)
TASK LEVEL DETERMINED (I) II III
CODE 1 (2) 3 4

TIME START: 1028

OPERATOR NUMBER: 4





DATA SHEET #36

The job was performed under standard conditions. The technician was informed of the faults at 0830; decided what to do, and proceeded to get parts and tools at 0835. The unit was worked on from 0845 to 0915 and again from 0925 to 0947 when it was finished. After washing the vehicle the horn was found to be inoperative. Repairs were made from 1014 to 1021 and assistance was given for 3 minutes by another technician. The vehicle was checked at 1023 and the job approved at 1025.

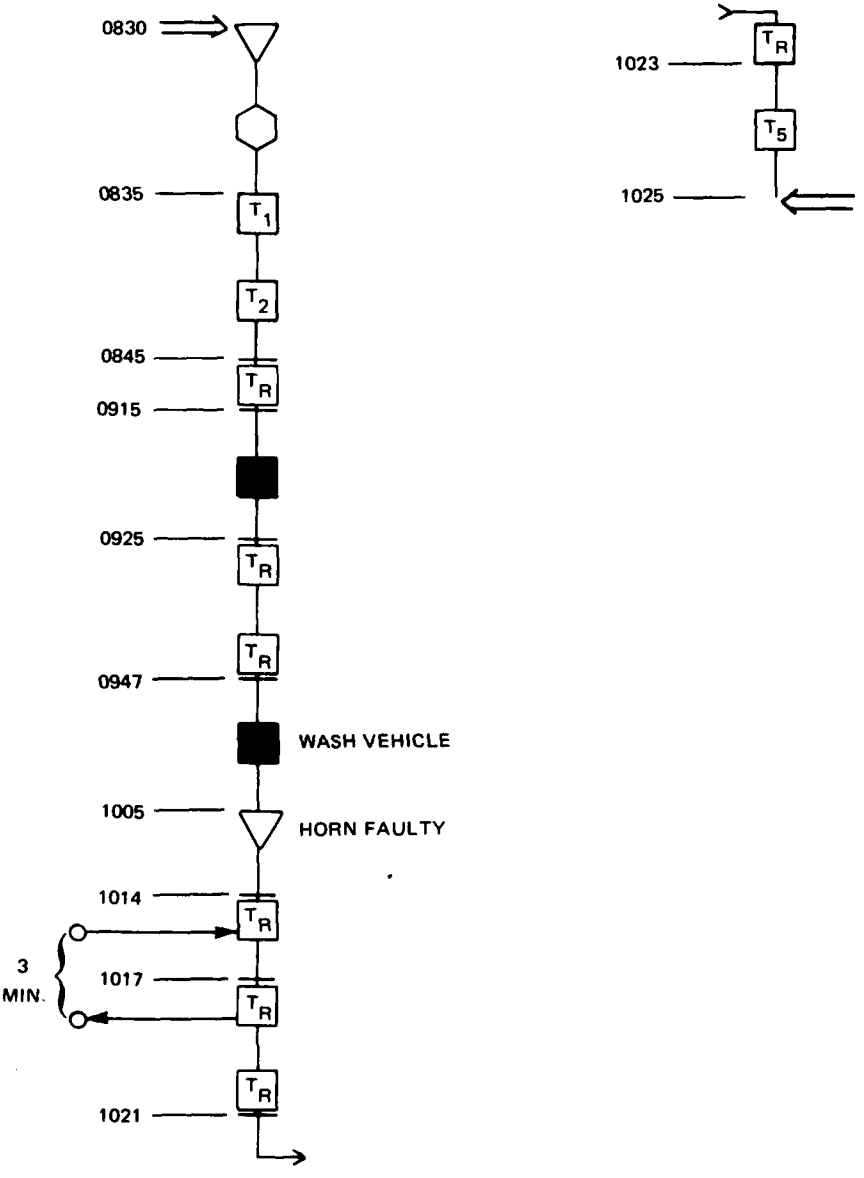
DATA SHEET 36
GROUP NUMBER II

DATE: 6 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 822

FAULT LISTED: WILL NOT START
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I (II) III
CODE (1) 2 3 4

TIME START: 0830

OPERATOR NUMBER: 1



DATA SHEET #37

The job was performed under standard conditions. Technician #4 was informed of the "gripe" at 1040. He had assistance troubleshooting for 8 minutes, during which time he used the wiring diagrams (standard manual) two times. At 1218 the removal of the parts considered at fault started and continued until 1233 except for getting tools. The proper parts were installed from 1233 to 1247 and the system checked. The failure had not been remedied. Technician #4 asked another technician for assistance and from 1249 to 1305 the wiring diagram was referred to 5 times as different men helped troubleshoot the system. At 1405 the system was checked again; the fault persisted. Technician #1 helped troubleshoot from 1415 to 1440. Information concerning the wiring was checked in the wiring diagrams 3 times. Technician #2 and technician #1 both assisted in attempting to solve the problem. At 1443 Technician #1 was replaced by Technician #3 and he and Technician #2 continued work with the assigned operator #4 until the end of the work period. The job was carried over to the next day. For continuation, see DATA SHEET #38.

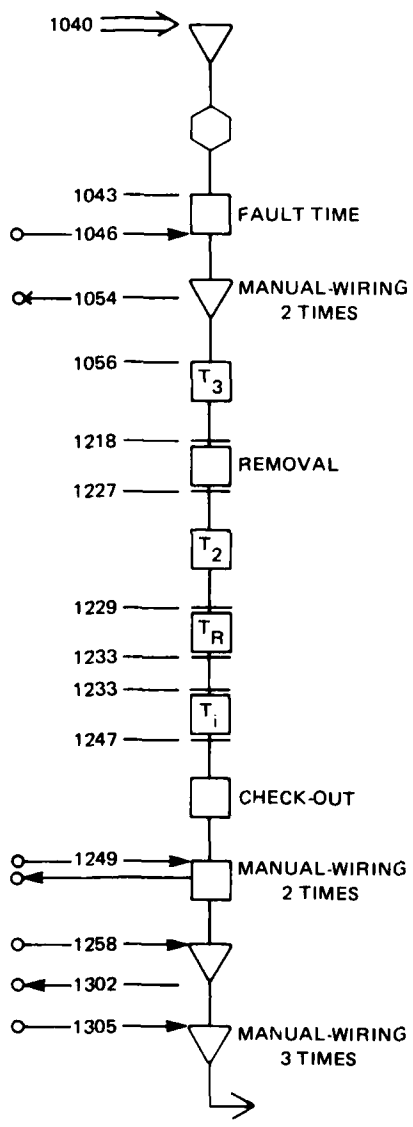
DATA SHEET 37
GROUP NUMBER II

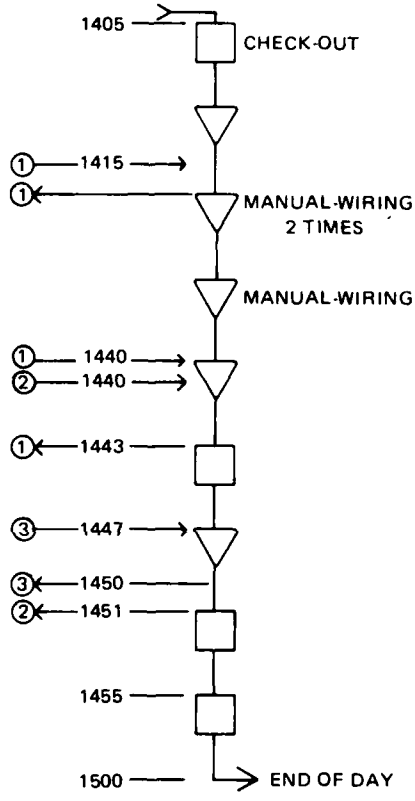
DATE: 18 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 054

FAULT LISTED: AC ON LIGHT STAYS ON (WET)
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I (II) III
CODE 1 (2) 3 4

TIME START: 1040

OPERATOR NUMBER: 4





DATA SHEET #38

Previous day's work was continued by operator #4 alone. Work on repairs started at 0718 and, with troubleshooting, continued to 0842. A check to determine if the "gripe" had been repaired was made between 0842 and at 0845. Additional information was given and received by another technician as a result of which a load test was made. Operator #4 had assistance in troubleshooting for the next three minutes. The trouble was considered found and the assistant left at 0855. The manual wiring diagram was used twice to check out the function of the system and at 0916 the system was considered repaired. This action is considered a normal activity in "fixing" a "gripe" in the electrical section. Every electrical rating in the work center was used at one time or another in this action.

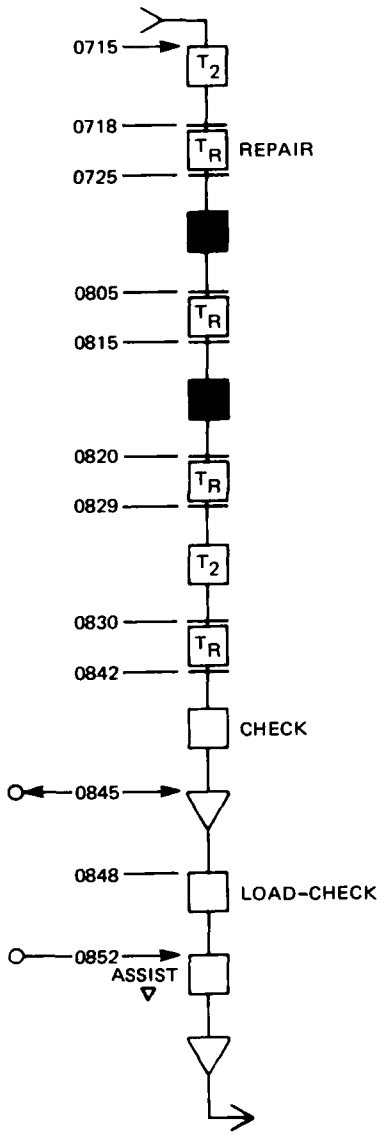
DATA SHEET 38
GROUP NUMBER 1

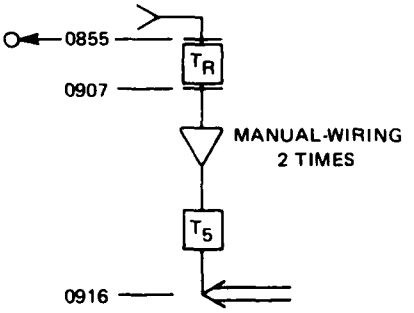
DATE: 20 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 054

FAULT LISTED: AC ON LIGHT STAYS ON (CONT.)
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I (II) III
CODE 1 (2) 3 4

TIME START: 0715

OPERATOR NUMBER: 4





DATA SHEET #39

This job was performed under JPA conditions phase II. Technician #3 was informed of the gripe but made a wrong decision in procedure. The record shows that he changed the solenoid correctly, but the vehicle failed to start. Trouble-shooting did not actually start until 0913 when a defective fuse was found. The fuse was replaced at 0915 and the vehicle checked and found to be operative. Operator #3 was experienced, but did not check the "gripe" until after changing the parts which "if bad" could cause the "gripe" given. Our records do not follow disposition of the parts removed as they are checked later.

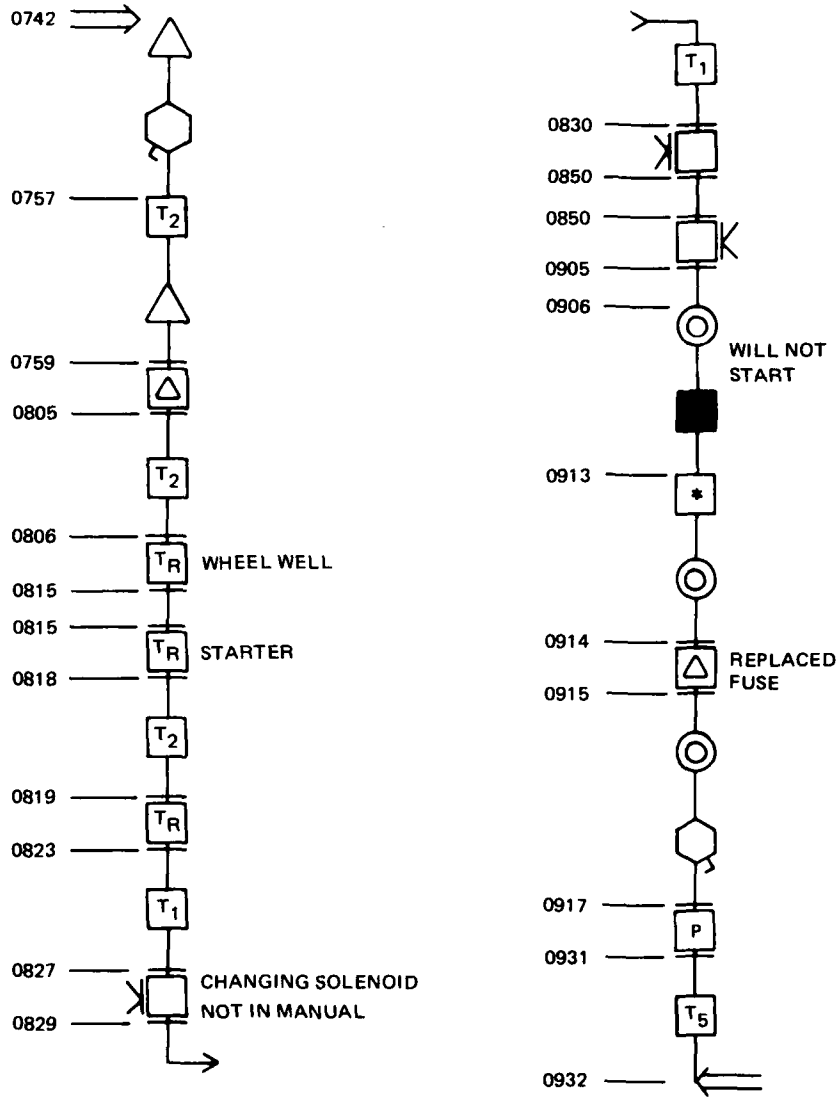
DATA SHEET 39
GROUP NUMBER I

DATE: 11 JULY '72
STATION: LEMOORE
SERIAL NUMBER: 215

FAULT LISTED: STARTER INOPERATIVE
SPECIALIST E OR (M)
TASK LEVEL DETERMINED I (II) III
CODE (1) 2 3 4

TIME START: 0742

OPERATOR NUMBER: 3



DATA SHEET #40 and #41

This job was performed under JPA phase II conditions. Technician #1 was informed of the "gripe" at 1421 and started troubleshooting at 1422. He checked the JPA for his operations and made what turned out to be the correct decision on what to do. The job followed JPA procedures for replacing a bad mode selector switch. The "gripe" was fixed by 1000 the following day.

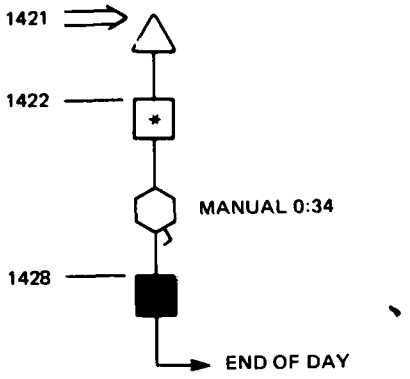
DATA SHEET 40
GROUP NUMBER I

DATE: 17 JULY '72
STATION: LEMOORE
SERIAL NUMBER: 056

FAULT LISTED: BAD MODE SEL. SWITCH
SPECIALIST (E) OR M
TASK DETERMINED I (II) III
CODE (1) 2 3 4

TIME START: 1421

OPERATOR NUMBER: 1



BLANK PAGE

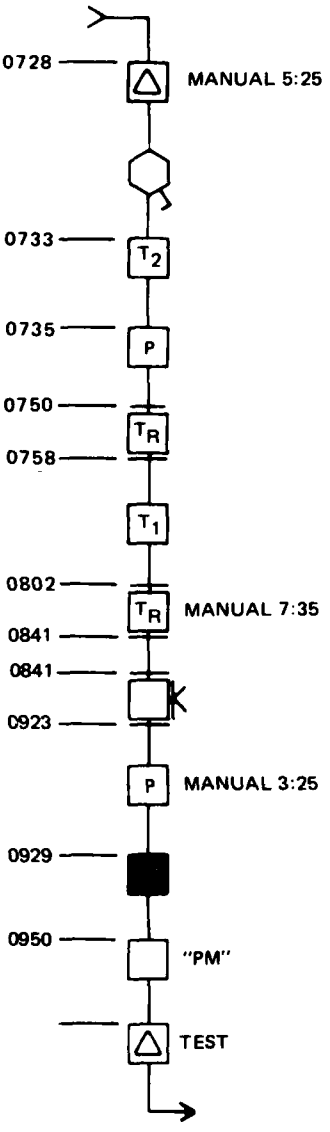
DATA SHEET 41
GROUP NUMBER I

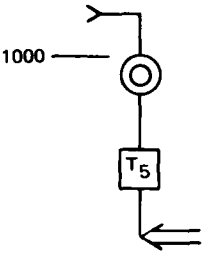
DATE: 18 JULY '72
STATION: LEMOORE
SERIAL NUMBER: 056

FAULT LISTED: BAD MODE SELECTOR SWITCH (Cont.)
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I (II) III
CODE (1) 2 3 4

TIME START:

OPERATOR NUMBER





DATA SHEET #42

The job was performed under JPA phase II conditions. Technician #3 was given information concerning the "gripe" at 1420. Troubleshooting was started and by 1446 the correct fault was found. The job continued to the end of the work day and was carried over. For continuation, see DATA SHEET #43.

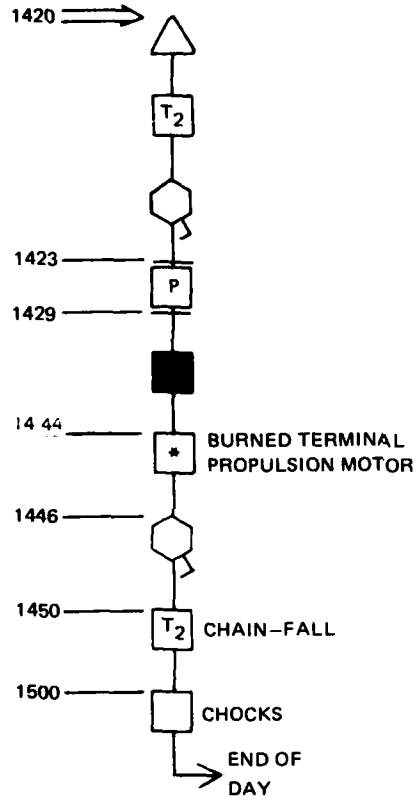
DATA SHEET 42
GROUP NUMBER I

DATE: 17 JULY '72
STATION: LEMOORE
SERIAL NUMBER: 171

FAULT LISTED: NO PROPULSION
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I II (III)
CODE 1 2 3 4

TIME START: 1420

OPERATOR NUMBER: 3



DATA SHEET #43

The previous day's work continued. Work started at 0735 using the JPA with assistance from two technicians from 0854 to 0900. The work on the "gripe" was actually finished by 1100. However, a "PM" in the mechanical shop section and road testing, plus adjustments of the engine required the technician's efforts until 1404.

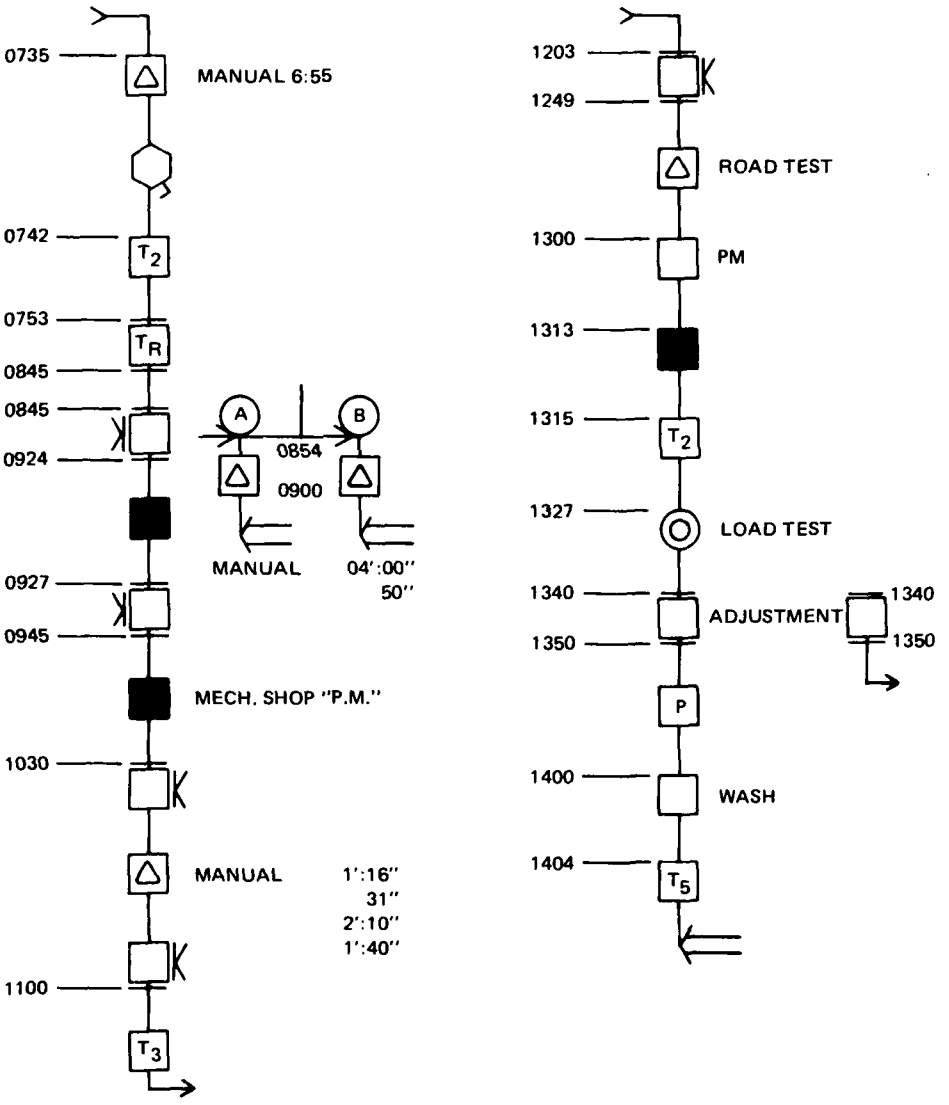
DATA SHEET 43
GROUP NUMBER I

DATE: 19 JULY '72 (cont.)
STATION: LEMOORE
SERIAL NUMBER: 171

FAULT LISTED: NO PROPULSION (CONT.)
SPECIALIST (E) OR M
TASK LEVEL DETERMINED I II (II)
CODE 1 2 3 4

TIME START: 1420

OPERATOR NUMBER: 3



DATA SHEET #44

The job was performed under JPA phase II conditions. Technician #2 was given information concerning the fault at 0755. He studied the JPA and using previously acquired knowledge of such "gripes" determined correctly what had to be done. A removal was made at 0759 and a replacement from 0808 to 0814. Using the JPA the required work was actually finished at this point. Essential PM work was then performed and the vehicle checked out as repaired by 0900.

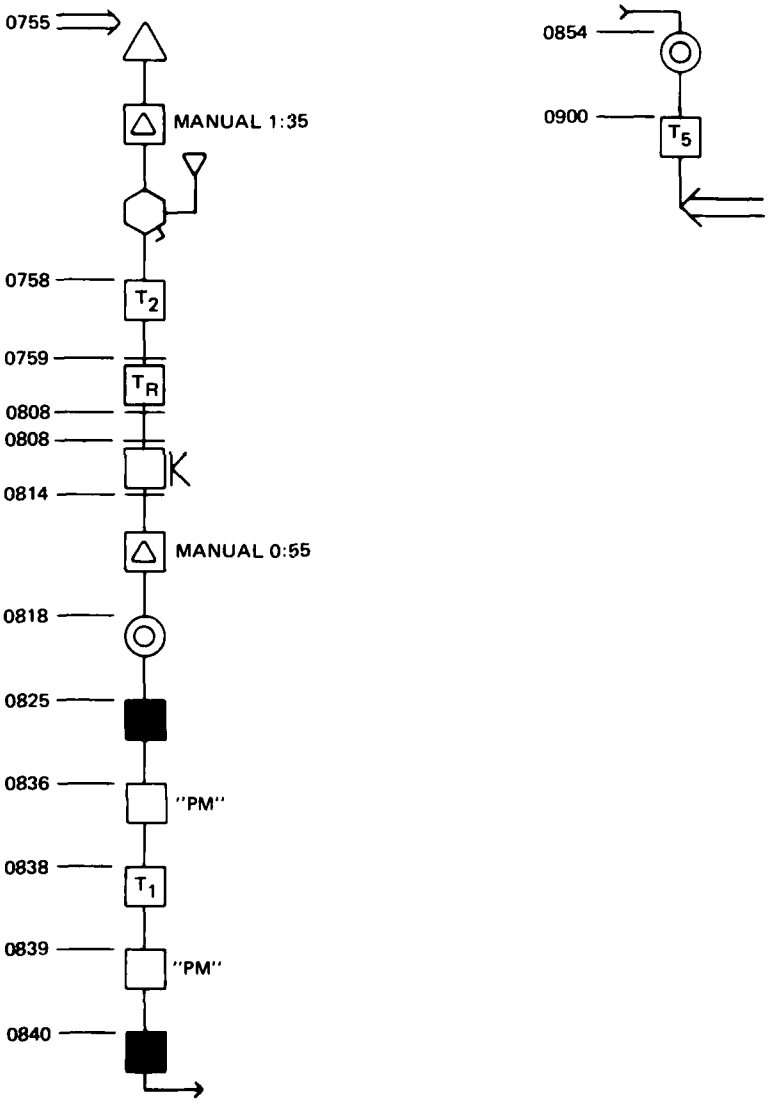
DATA SHEET 44
GROUP NUMBER I

DATE: 14 JULY '72
STATION: LEMOORE
SERIAL NUMBER: 250

FAULT LISTED: OVER VOLTAGE MODULE
SPECIALIST (E) OR M
TASK LEVEL DETERMINED (I) II III
CODE (1) 2 3 4

TIME START: 0755

OPERATOR NUMBER: 2



DATA SHEET #45 and #46

The job was performed under JPA phase II conditions. Technician #4 was informed of the gripe. He had previous knowledge of this piece of gear. His decision of what had to be done was correct. Using the JPA the job consisted of removals and replacements with only three periods, from 0825 to 0833, 0917 to 0933 and 0938 to 0940 for adjustments and repair. The particular adjustments and the alternation of the brake system were all shown in the JPA. The "gripe" was fixed and the unit checked out by 0955.

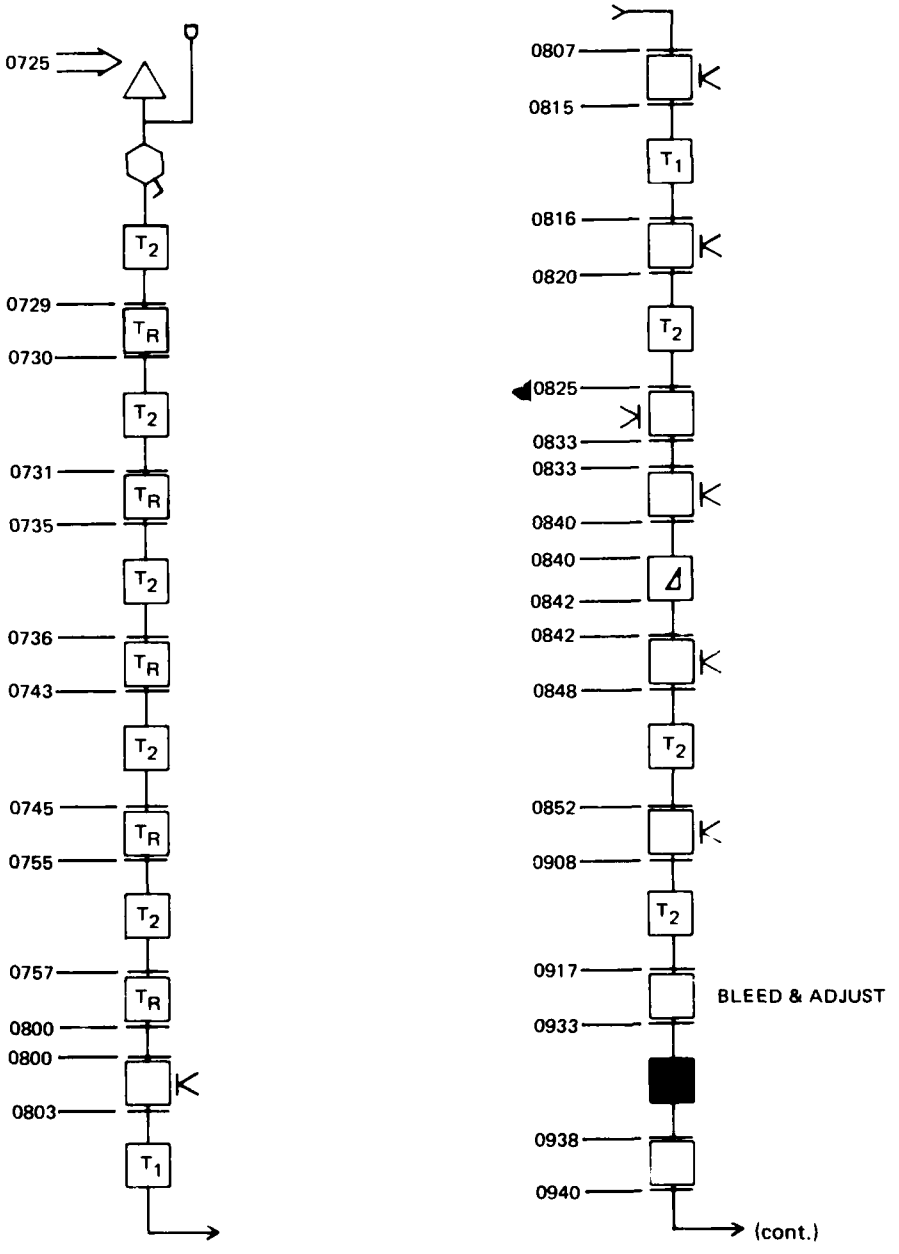
DATA SHEET 45
GROUP NUMBER I

DATE: 19 JULY '72
STATION: LEMOORE
SERIAL NUMBER: 242

FAULT LISTED: PULLS TO THE RIGHT
SPECIALIST E OR (M)
TASK LEVEL DETERMINED I (II) III
CODE 1 (2) 3 4

TIME START: 0725

OPERATOR NUMBER: 4



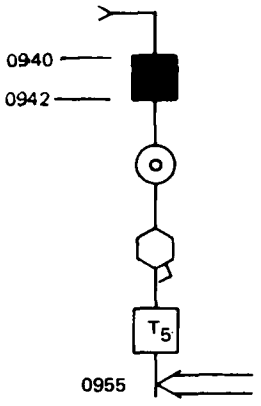
BLANK PAGE

DATA SHEET 46
GROUP NUMBER I

DATE: 19 JULY '72 (cont)
STATION: LEMOORE
SERIAL NUMBER: 242

FAULT LISTED: PULLS TO THE RIGHT (CONT.)
SPECIALIST E OR (M)
TASK LEVEL DETERMINED I (II) III
CODE 1 (2) 3 4

OPERATOR NUMBER: 4



DATA SHEET #47

The job was performed under JPA phase III conditions. Technician #3 was informed of the "gripe". Before starting the job the technician was given a briefing on the required use of the JPA and what his responsibilities would be. He actually started work on the vehicle at 0751. By 0753 he had a fault in maintenance, logged against him for not following the JPA format. The chart shows that this error was followed by 24 minutes of discussion concerning the use of the manual. The job then continued at 0817 with a new part from the supply room and assisted by the troubleshooter "M", advising what to do, as required. The rest of the flow chart is straight forward; a remove and replace operation, checking out as approved at 1031.

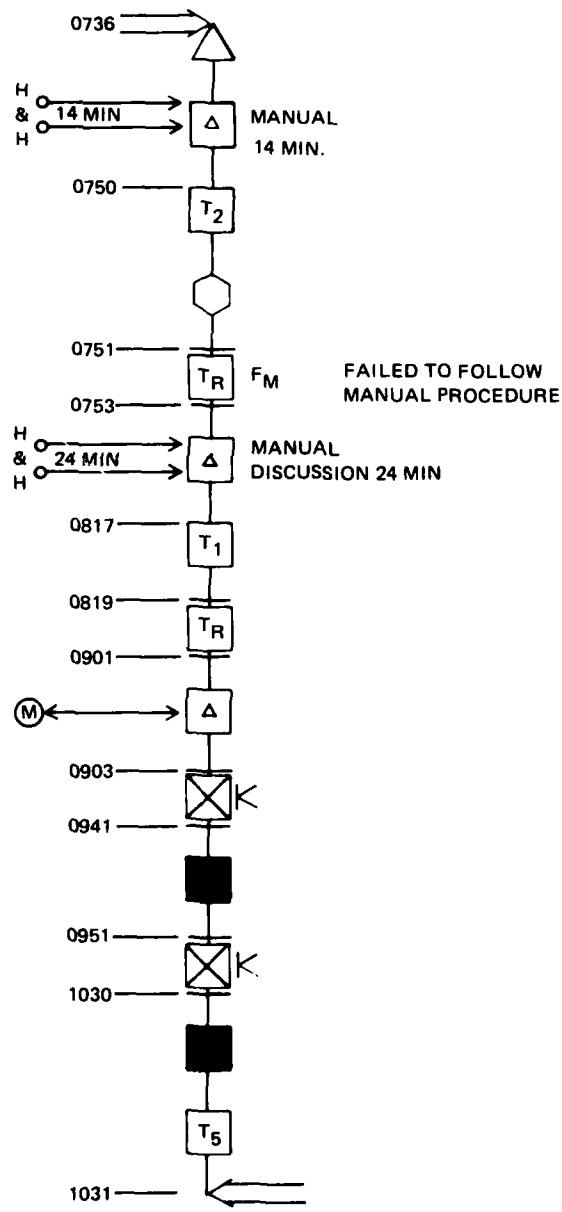
DATA SHEET 47
GROUP NUMBER III

DATE: 8 AUGUST '72
STATION: LEMOORE
SERIAL NUMBER: 244

FAULT LISTED: BAD MODE SELECTOR SWITCH
SPECIALIST E OR (M)
TASK LEVEL DETERMINED I (II) III
CODE 1 (2) 3 4

TIME START: 0736

OPERATOR NUMBER 3



DATA SHEET #48

The job was performed under JPA phase III conditions. Technician #3 was informed on the "gripe" and what to do at 1245. The broken part was removed using the JPA from 1250 to 1258. The new part was installed and the job finished and checked by 1346.

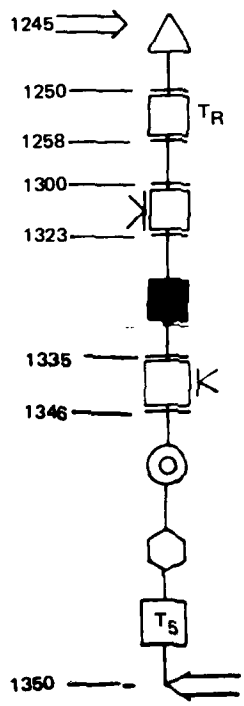
DATA SHEET 48
GROUP NUMBER III

DATE: 16 AUGUST '72
STATION: LEMOORE
SERIAL NUMBER: 176

FAULT LISTED: MASTER CYLINDER BROKE
SPECIALIST (E) OR M
TASK LEVEL DETERMINED (I) II III
CODE 1 2 3 4

TIME START: 1245

OPERATOR NUMBER: 3



DATA SHEET #49

The job was performed under JPA phase III conditions. Technician #3 was informed of the "gripe" at 1304. This particular job required "troubleshooting" and testing. Actual repairs did not start until 1323 and required only 2 minutes. This is typical of many jobs; the longest and most difficult part of the task was to actually determine what had to be done. The "gripe" was fixed and the job checked out at 1343.

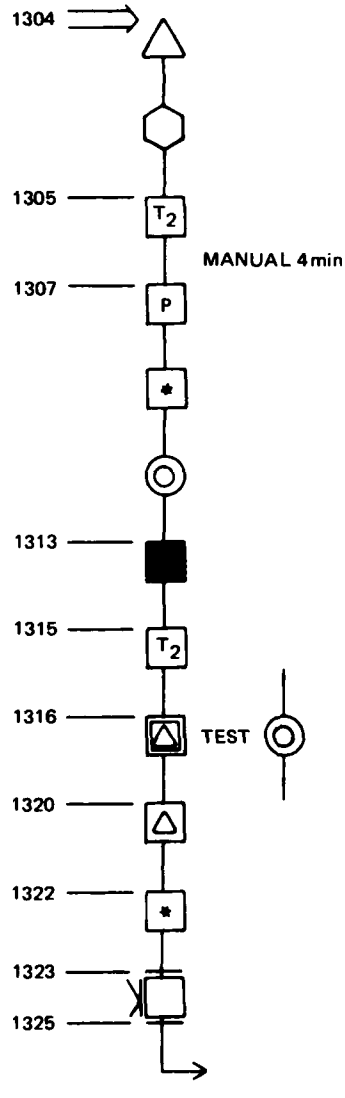
DATA SHEET 49
GROUP NUMBER III

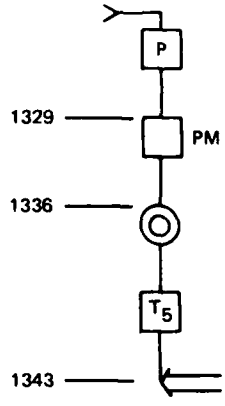
DATE: 17 AUGUST '72
STATION: LEMOORE
SERIAL NUMBER: 176

FAULT LISTED: FREQUENCY ADJUSTMENT
SPECIALIST E OR (M)
TASK LEVEL DETERMINED (I) II III
CODE 1 (2) 3 4

TIME START: 1304

OPERATOR NUMBER: 3





DATA SHEET #50

The job was performed under JPA phase III conditions. Technician #4 was informed of the gripe and given information by the troubleshooter at 0953. The decision of what to do was correct. The instructions following the JPA plus work by the troubleshooter was required from 1004 to 1026. The "gripe" was fixed and checked out at 1026.

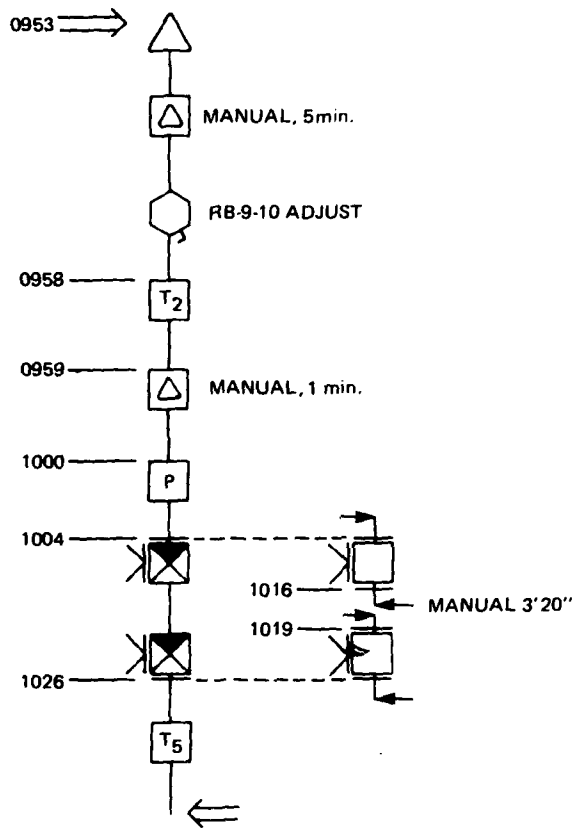
DATA SHEET 50
GROUP NUMBER III

DATE: 8 AUGUST '72
STATION: LEMOORE
SERIAL NUMBER: 055

FAULT LISTED: UNDER FREQUENCY
SPECIALIST E OR (M)
TASK LEVEL DETERMINED (I) II III
CODE 1 (2) 3 4

TIME START: 0953

OPERATOR NUMBER: 4



DATA SHEET #51 and #52

The job was performed under JPA phase III conditions. Technician #2 was informed of the "gripe" at 1023. This action started out as a straight remove and replace operation by the JPA. At 1029 the battery shop had a man remove the old battery and install a new one. He finished at 1100. At the same time, technician #2 was proceeding to remove the starter. At 1219 the troubleshooter checked his work, gave him information concerning starters, and watched while he replaced the starter. The unit did not start after the work was finished and a fault was recorded. Troubleshooting and a check of the system indicated that the new battery was at fault. The battery was changed at 1310 and the task was essentially finished. By 1357 the unit was checked-out and approved.

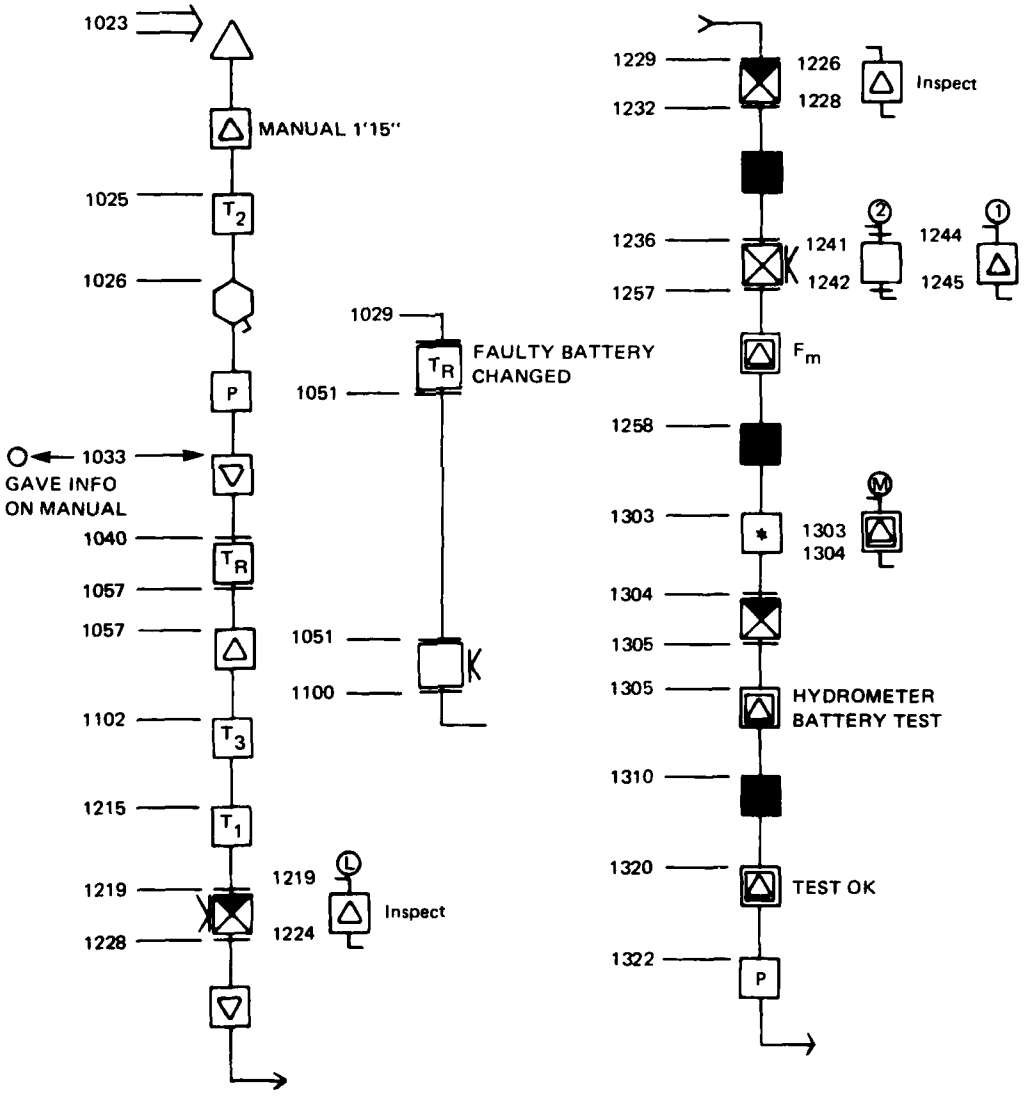
DATA SHEET 51
GROUP NUMBER III

DATE: 15 AUGUST '72
STATION: LEMOORE
SERIAL NUMBER: 242

FAULT LISTED: BAD STARTER
SPECIALIST E OR (M)
TASK LEVEL DETERMINED I (II) III
CODE 1 (2) 3 4

TIME START: 1023

OPERATOR NUMBER: 2



BLANK PAGE

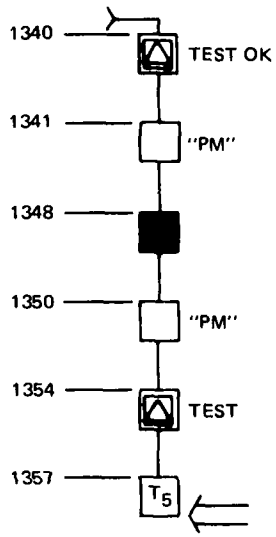
DATA SHEET 52
GROUP NUMBER III

DATE: 15 AUGUST '72
STATION: LEMOORE
SERIAL NUMBER: 242

FAULT LISTED: BAD STARTER (Cont.)
SPECIALIST E OR (M)
TASK LEVEL DETERMINED I (II) III
CODE (1) 2 3 4

TIME START: 1023

OPERATOR NUMBER 4



DATA SHEET #53

The job was performed under standard conditions. Technician #4 was given the "gripe" at 1010. He proceeded to discuss the job with another technician, placed the unit on the lift to inspect it and then proceeded to read the "gripe". He then received information concerning how to do the job from another technician, and at 1020 he picked up some tools. At 1035 technician #1 assisted in getting the correct special tools for the job. Technician #1 working with technician #4 proceeded to demonstrate how the job could be done until 1038. Technician #4 worked alone for 2 minutes then required new tools. At 1302 technician #4 worked alone for 3 minutes after which he was again helped by technician #1. At 1319 technician #1 left and technician #4 worked alone for 14 minutes during the remainder of the work day. The job was carried over to the next day.

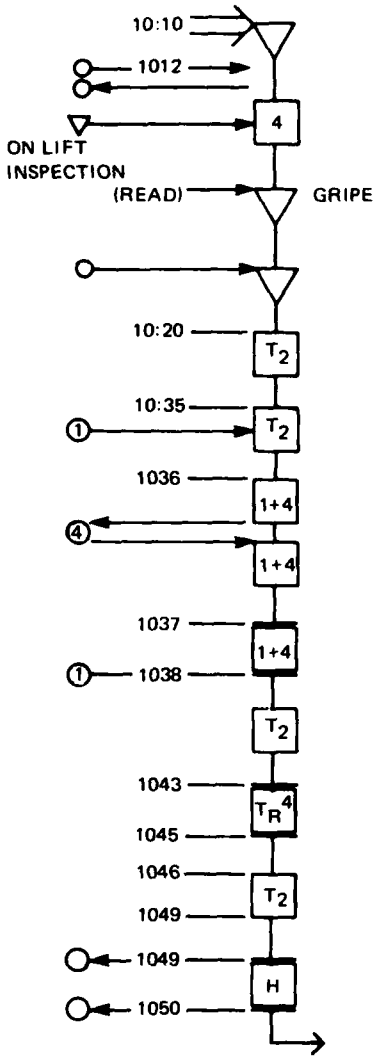
DATA SHEET 53
GROUP NUMBER II

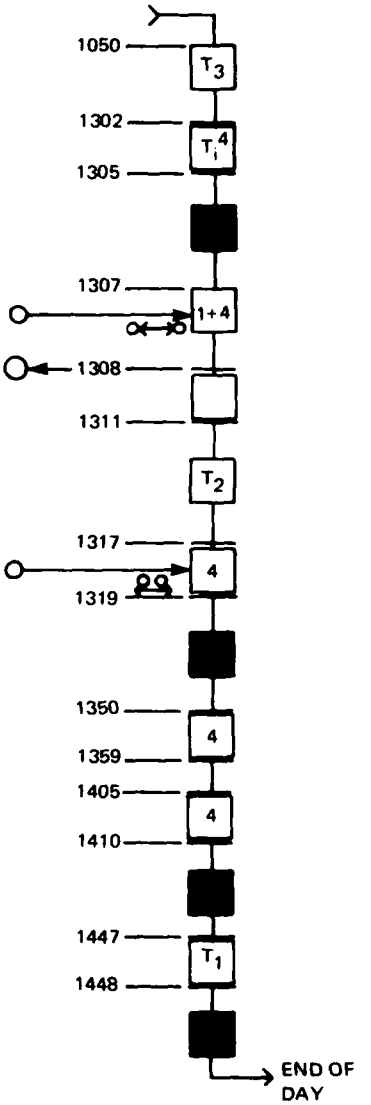
DATE: 13 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 241

FAULT LISTED: GENERATOR BOLT BROKEN
SPECIALIST: E OR (M)
TASK LEVEL DETERMINED I II III
CODE 1 (2) 3 4

TIME START: 10:09

OPERATOR NUMBER 4





DATA SHEET #54

The previous work continues. Technician #4 finished the job alone and checked it out by 1030. This entire operation indicates the normal method of on-the-job training as it actually works. In this instance the technician received information from three different mechanics and actually had a large part of the work performed by one of them. No standard of "on-the-job" instruction actually exists, nor are the "helpers" qualified as instructors.

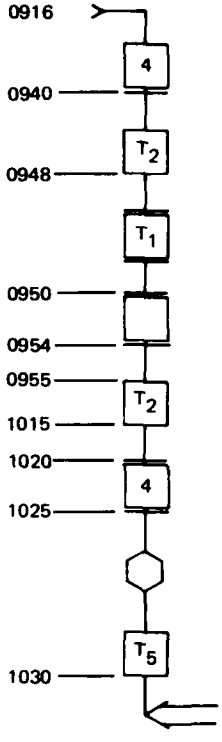
DATA SHEET 54
GROUP NUMBER II

DATE: 14 APRIL '72
STATION: LEMOORE
SERIAL NUMBER: 241

FAULT LISTED: GENERATOR BOLT BROKEN (CONT.)
SPECIALIST: E OR (M)
TASK LEVEL DETERMINED I (II) III
CODE 1 (2) 3 4

TIME START: 0916

OPERATOR NUMBER 4



APPENDIX D

The contents of this Appendix include information on the scholastic and technical training of the Naval personnel from NAS Lemoore, NAS Miramar and NAS Quonset Point that participated in the test program. It also contains information concerning the specific training of the Human Factors Study Group observers.

PERSONNEL DATA

Rate	Age	Enlist Time	Yrs. Educ.	Degree	Get Scores	Mech. Aptitude Test	Grad NC-8A School
ASM-3	22	3	12	---	46	43	---
ASM-3	23	2	12	---	59	63	---
CM-3	22	3.6	12	---	50	52	---
ASM-3	22	3	12	---	66	65	---
ASE-3	22	3.5	12	---	62	63	Yes
ASE-2	23	3	14	Certif.	65	67	Yes
ASE-3	22	3	13	---	--	--	---*
AA	20	1	9	---	--	--	---*
ASM-3	21	2	12.5	---	68	60	---
ASM-3	22	2	14	---	66	52	---
ASE-3	23	3	12	---	64	63	Yes
ASE-3	23	3	14	Certif.	63	64	---
ASE-3	22	3	12	---	61	66	Yes
ASE-2	22	3	13	---	55	61	---
ASE-3	25	3	12	---	63	74	---
ASE-2	23	2	12.5	---	66	66	---
ASE-2	30	4	12	---	54	49	Yes
ASM-3	23	3	13	---	61	65	Yes
ASE-3	23	3	12	---	60	50	Yes
ASE-3	20	3	12	---	72	66	---
ASE-3	22	3	12	---	70	65	Yes
AN	21	1	12	---	58	55	---
AN	21	1	12	---	69	63	---
ASM-3	22	3	12	---	47	60	---
AN	22	1	12	---	67	56	---
AN	22	1	12	---	56	55	---

* Used as temporary replacement

RECAP

Personnel Statistics

Total technicians - 26
- 17 3rd class P.O.
- 4 2nd class P.O.
- 5 unrated strikers

All age Range	20 - 23	Average 22 yr.
Enlistment Yrs.	1 - 4	Average 2.54
Years Schooling	9 - 14	Average 12
Get Scores	46 - 69	Average 61
Mech. Scores	43 - 74	Average 60
NC-8A Grads.		8

Observers

Before the field testing started, the observers had a period of specific training in observation techniques and use of "O.S.D." at local Naval Air Stations and in the laboratory. However, bias due to differences in the reporting and recording of the events by the observers, particularly at the beginning of the program was expected. This was partially avoided, or at least reduced, by an initial period of duplicate studies (Two observers recorded flow charts of the same events independently and the results were checked point by point for time and events.) in the field during Phase I. "Hands on" time in agreement to within 1 minute was required before either member of the pair was considered qualified to record alone.

APPENDIX E

TESTS PERFORMED AND DATA

1. Tests and Analyses

Below is a list of all the statistical test used in the test program. The actual calculations and explanations of how each test was used can be found in the following pages.

a. χ^2 for Two Independent Samples
Errors vs. Non-error, Standard vs. JPA Phase II
Errors vs. Non-error, Standard vs. JPA Phase III
Errors vs. Non-error, Level I (Stand) vs. Level I (JPA, Phase II)

b. One Sample Run Test
Errors vs. Non-errors in Standard JPA Phase II and III
Errors vs. Non-errors in Standard, JPA Phase II and III in Remove and Replace Actions only.

c. F Test, .05 Level of Confidence

Standard Test, Phase I
Among all 4 operator (Mech.) in Level I
Among all 4 operator (Mech.) in Level II
Among all 4 operator (Elec.) in Level I
Among all 4 Operator (Elec.) in Level II

Level I (Mech.) vs. Level I (Elec.)
Level II (Mech.) vs. Level II (Elec.)

Level I (Lemoore) vs. Level I (Miramar)
Level II (Lemoore) vs. Level II (Miramar)

JPA, Phase II
Level I (Elec.) vs. Level I (Mech.)
Level II (Elec.) vs. Level II (Mech.)

Level I (Std.) vs. Level I (Phase II)
Level II (Std.) vs. Level II (Phase II)

JPA, Phase III
Level I (Elec.) vs. Level I (Mech.)

Level I (Std.) vs. Level I (Phase III)
Level II (Std.) vs. Level II (Phase III)

2. χ^2 (chi-square) Test for Two Independent Samples

Where the data consists of frequencies or populations in discrete categories, i.e. separable units, the χ^2 test can be used to determine the significance of differences between two independant groups. The technique is based on counting the number of cases (number of maintenance actions involved in the test under question) from each group (the particular phase of the three phases of the test program) which falls in the various categories (either error or non-error maintenance action), and comparing the proportion of cases from one group in the various categories with the proportion of cases from the other group.

Method

The null hypothesis may be tested by:

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{k} \frac{(Oij - Eij)^2}{Eij}$$

where:

Oij = Observed number of cases categorized in the i^{th} row of j^{th} column.

Eij = Number of cases expected under H_o to be categorized in i^{th} row of j^{th} column.

$\sum_{i=1}^{r} \sum_{j=1}^{k}$ directs one to sum over all (r) rows and all (k) columns, i.e., to sum over all cells.

H_o: Conditions under which errors occur are the same in both phases.

For a 2 X 2 Contingency Table, as it is the case in this report, this method can be simplified as follows:

	Category	
Phase	A	B
	C	D

where:

$$N = A + B + C + D$$

A, B, C, D are the number of maintenance actions in each cell and N is the total number of maintenance actions, then;

$$\chi^2 = \frac{N\left(|AD-BC| - \frac{N}{2}\right)^2}{(A+B)(C+D)(A+C)(B+D)}$$

with 1 degree of freedom

The three Contingency Tables used in this report are as follows:

a.

	Error Actions	Error-Free Actions
Phase I	31	51
Phase II	7	31

120

$\chi^2 = .321$, 1 d. of f.

Therefore, the probablility of occurrence under H_o is $p < .30$. Inasmuch as p is greater than .05, H_o cannot be rejected.

b.

	Error Actions	Error-Free Actions
Phase I	31	51
Phase III	9	19

110

$\chi^2 = .67$, 1 d. of f.

Therefore, the probability of occurrence under H_o is $p < .25$. Inasmuch as p is greater than .05, H_o cannot be rejected.

c.

	Error Actions	Error-Free Actions
Phase I, Level I	21	67
Phase II, Level I	0	22

110

$\chi^2 = 5.05$, 1 d. of f.

Therefore, the probability of occurrence under H_o is $p < .01$. Inasmuch as this p is less than .05, the decision is to reject H_o.

3. One-Sample Run Test

The technique is based on the number of runs* which a sample† exhibits.

*Run; A succession of identical symbols which are followed and preceded by different symbols or by no symbols at all.

†Sample; In this particular test, it is defined as all the maintenance actions that took place in the three phases of the test program.

Method

Let "+" stand for error-free actions.
Let "-" stand for actions in which errors were made.
n_1 = number of "+"
n_2 = number of "-"
$N = n_1 + n_2$
r = number of runs
H_o (Null Hypothesis): Errors occur randomly, no difference in different phases of test.
Actions were arranged in chronological order, by starting time, and labeled "+" or "-".

a. Error-Free vs. Error Action for all actions:

$N = 151$
$r = 54$
$n_1 = 113$
$n_2 = 38$

b. Error-Free vs. Error Action for "Remove and Replace" actions only:

$N = 59$
$r = 26$
$n_1 = 43$
$n_2 = 16$

By substituting these values in

$$Z = \frac{r - \left(\frac{2n_1n_2}{N} + 1\right)}{\sqrt{\frac{2n_1n_2\ (2n_1n_2-N)}{(N)^2\ (N-1)}}}$$

A value for Z is obtained. With this value and the proper table, the probability of occurrence of H_o can be determined.

For "a" Z = .55, giving a probability of occurrence of .58. This value exceeds the .05 level of confidence. Therefore, H_o cannot be rejected.

For "b" Z = .16, giving a probability of occurrence of .86. Again, H_o cannot be rejected.

4. F Tests

The technique is based on calculating (as in the following pages) the "variance between sets"* (S_b^2) and "variance within sets" (S_w^2). The ratio of S_w^2 to S_b^2 gives a value of F which is compared to the critical value of F given in the appropriate table.

Tables are available for different "Levels of Confidence". For these tests, the .05 level of confidence is used. If the calculated value of F is greater than the value found in the table, H_o is rejected; H_o being the "Null Hypothesis" that the determinations are from the same population.

NOTE: The determinations represent hands-on-time in minutes for each maintenance action.

*Definition; A task level, training of a technician, or station. For a list of all sets used refer to page E-1, paragraph C.

a. NAS Lemoore Phase I Level I

Set	Mech	Elec
Determinations	1 min.	39 min.
	35	1
	11	1
	2	38
	3	38
	18	45
	3	10
	13	2
	29	10
	30	12
	38	26
		7
		7
		7
		4
		47
		44
		24
		10
		6
		28
		42
		22
		7
		18
		25
		8
		19
		26
		47
		23
		43
TOTAL	183	686
Number of Analyses (n)	12	27
Sum of Squares	4,169	20,418
$\frac{(\text{Total})^2}{n}$	2,563	17,429
Difference	1,606	2,989

$$S_w^2 = \frac{(1,606 + 2,989)}{(12-1) + (27-1)}$$

$$= \frac{4595}{37}$$

$$= 124 \quad \text{with 37 degrees of freedom}$$

	MECH	ELEC	MECH & ELEC
Total	183	686	869
n	12	27	39
Average per set	15.25	25.40	22.28
$\frac{(\text{Total})^2}{n}$	2,563	17,429	19,563

$$S_b^2 = \frac{(2{,}563+17{,}429) - 19{,}563}{2-1} = 429$$

with 1 degree of freedom

$$F = \frac{429}{124}$$

$$= 3.45$$

Critical value of F = 4.1

b. NAS Lemoore Phase I Level II

Set	Mech	Elec
Determinations	80 min.	132 min.
	125	80
	116	142
	72	75
	145	135
	117	62
		97
		57
		53
		55
		77
		127
		136
		104
		111
		64
		135
		105
		94
		122
		141
		79
		67
		103
		99
		77

Set	Mech	Elec
		128 min.
		74
		65
		66
TOTAL	655	2862
Number of Analyses (n)	6	30
Sum of Squares	75,379	298,322
$\frac{(\text{Total})^2}{n}$	71,504	273,035
Difference	3,875	25,287

$$S_w^2 = \frac{29162}{34} = 857.7$$ with 34 degrees of freedom

	Mech	Elec	Mech & Elec
Total	655	2862	3517
n	6	30	36
Average per set	109.17	95.40	97.69
$(\text{Total})^2$	429,025	8,191,044	12,369,289
$\frac{(\text{Total})^2}{n}$	71,504	273,035	343,591

$$S_b^2 = \frac{948}{2-1} = 948$$ with 1 degree of freedom

$$F = \frac{948}{857} = 1.11$$

Critical value of F = 4.09

c. NAS Lemoore and NAS Miramar, Phase I, Level I

Set	Lemoore	Miramar
Determinations	(see previous data)	6 min.
		36
		49
		28
		28
		46
		28
		7
		16

Set	Lemoore	Miramar
		9 min.
		8
		22
		32
		16
		42
		20
		6
		15
		15
		14
		39
TOTAL	869	478
Number of Analyses (n)	39	21
Sum of Squares	24,587	15,942
$\frac{(\text{Total})^2}{n}$	19,563	12,080
Difference	5,024	3,862

$S_w^2 = \frac{8,886}{58} = 153$ with 58 degrees of freedom

	Lemoore	Miramar	L+M
Total	869	478	1347
n	39	21	60
Average per set	22.8	22.76	22.45
$\frac{(\text{Total})^2}{n}$	19,563	11,080	30,240

$S_b^2 = 403$ with 1 degree of freedom

$F = \frac{403}{153} = 2.63$

Critical Value of F = 4.0

d. NAS Lemoore and NAS Miramar, Phase I, Level II

Set	Lemoore	Miramar
Determinations	(see previous data)	96 min.
		104
		52
		88
		65
		81
		54
TOTAL	3517	540

Number of Analyses (n)	36	7
Sum of Squares	373,699	44,182
$\frac{(\text{Total})^2}{n}$	343,591	41,657
Difference	30,108	2,525

$$S_w^2 = \frac{32633}{41} = 795.93 \quad \text{with 41 degrees of freedom}$$

	Lemoore	Miramar	L&M
Total	3,517	540	4,057
n	36	7	43
Average per set	97.69	77.14	94.35
$\frac{(\text{Total})^2}{n}$	343,591	41,657	382,773

$$S_b^2 = \frac{2475}{2-1} = 2475 \quad \text{with 1 degree of freedom}$$

$$F = \frac{2475}{795} = 3.11$$

Critical Value of F = 4.08

e. NAS Lemoore Phase II, Level I

Set	Elec	Mech
Determination	10 min.	55 min.
	4	18
	40	9
	15	20
	5	
	32	
	25	
	2	
	1	
	32	
	26	
	48	
	41	
	36	
	9	
	13	
	9	
	9	
TOTAL	357	102

Number of Analyses (n)	18	4
Sum of Squares	10,957	3,830
$\frac{(\text{Total})^2}{n}$	7,080	2,601
Difference	3,877	1,229

$$S_w^2 = \frac{5106}{20} = 255.3$$ with 20 degrees of freedom

	Elec	Mech	Elec & Mech
Total	357	102	459
n	18	4	22
Average per set	19.8	25.5	28.8
$\frac{(\text{Total})^2}{n}$	7,080	2,601	9,576

$$F = \frac{255}{105} = 2.4$$

$$S_b^2 = 105$$

Critical Value of F = 248

f. NAS Lemoore Phase II, Level II

Set	Elec	Mech
Determination	113 min.	85 min.
	79	89
	99	89
	95	52
	71	53
	165	75
	65	97
	67	
	62	
	76	
TOTAL	892	540
Number of Analyses (n)	10	7
Sum of Squares	88,436	43,615
$\frac{(\text{Total})^2}{n}$	79,566	41,657
Difference	8,870	1,958

$$S_w^2 = \frac{10,828}{15} = 721.9$$ with 15 degrees of freedom

	Elec	Mech	Elec & Mech
Total	892	540	1,432
n	10	7	17
Average per set	89.2	77.1	84.2
$\frac{(\text{Total})^2}{n}$	79,566	41,657	120,624

$$S_b^2 = \frac{599}{1}$$ with 1 degree of freedom

$$F = \frac{721.9}{599} = 1.21$$

Critical Value of F = 245

g. NAS Lemoore, Phases I and II, Level I

Set Determination	Phase I (see previous data)	Phase II
TOTAL	869	459
Number of Analyses	39	22
Sum of Squares	24,587	14,787
$\frac{(\text{Total})^2}{n}$	19,563	9,676
Difference	5,024	5,211

$$S_w^2 = \frac{10235}{59} = 173$$ with 59 degrees of freedom

	Phase I	Phase II	Phase I & Phase II
Total	869	459	1,328
n	39	22	61
Average per set	22.3	28.8	22.77
$\frac{(\text{Total})^2}{n}$	19,563	9,676	28,511

$S_b^2 = 728$ with 1 degree of freedom

$F = \frac{728}{173} = 4.2$

Critical Value of F = 4.00

h. NAS Lemoore, Phase I and III, Level I

Set	Phase I	Phase III
Determination	(see previous data)	49 min.
		15
		28
		29
		42
		2
		33
		43
		45
		43
		42
		2
TOTAL	869	373
Number of Analyses	39	12
Sum of Squares	24,587	14,693
$\frac{(\text{Total})^2}{n}$	19,563	11,594
Difference	5,024	3,099

$S_w^2 = \frac{8123}{49} = 165$ with 49 degrees of freedom

	Phase I	Phase II	Phase I & Phase III
Total	869	373	1,242
n	39	12	51
Average per set	22.8	31.1	24.3
$\frac{(\text{Total})^2}{n}$	19,563	11,594	30,546

$S_b^2 = 611$ with 1 degree of freedom

$F = \frac{611}{165} = 3.7$

Critical Value of F = 4.04

i. NAS Lemoore Phases I and III Level II

Set	Phase I	Phase III
Determination	(see previous data)	52 min.
		58
		83
		121
		51
		52
		84
		108
TOTAL	3,517	609
Number of Analyses	36	8
Sum of Squares	373,699	51,623
$\frac{(\text{Total})^2}{n}$	343,591	46,360
Difference	30,108	5,263

$S_w^2 = \frac{35,371}{42} = 842$ with 42 degrees of freedom

	Phase I	Phase III	Phase I & Phase III
Total	3,517	609	4,126
n	36	8	44
Average per set	97.7	76.1	93.8
$\frac{(\text{Total})^2}{n}$	343,591	46,360	386,900

$$S_b^2 = 3051$$ with 1 degree of freedom

$$F = \frac{3051}{842} = 3.62$$

Critical Value of F = 4.08

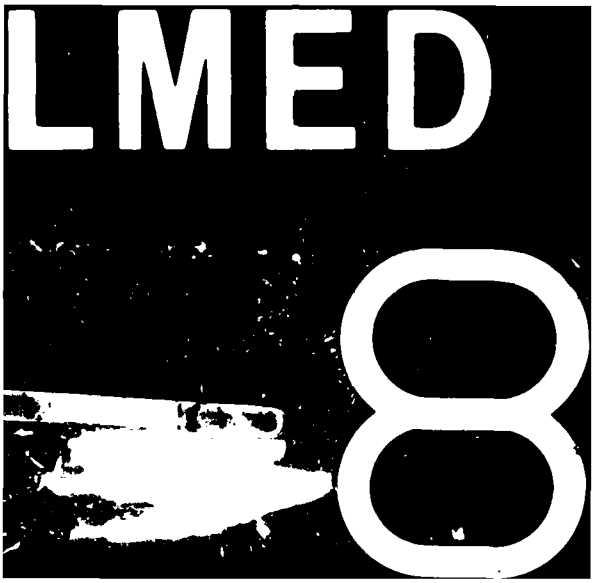
APPENDIX F

JOB PERFORMANCE AID
TEST PLAN

Report No. 7-72 March 1972

Prepared for the Commander, Naval Air Systems Command
(AIR-415B)

AIRTASK NO. A 260-415B-223D-2W45510003


LMED
8